Technical Report 536

DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS

VOLUME II: TECHNICAL DISCUSSION

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SYNECTICS CORPORATION

HUMAN FACTORS TECHNICAL AREA

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(Volume II)

This document is one of a series in the Final Report of Phase I in a project to develop design guidelines and criteria for user/operator transactions with battlefield automated systems. The report is organized in five volumes as follows:

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Item 20 (Cont'd)

I. Executive Summary (RR 1320)
II. Technical Report (this report)
III. In-Depth Analyses of Individual Systems
  A. Tactical Fire Direction System (TACFIRE) (RP 81-26)
  B. Tactical Computer Terminal (TCT) (RP 81-27)
  C. Admin/Log Automated Systems (RP 81-28)
  D. Intelligence Information Subsystem (IISS) (RP 81-29)
IV. Provisional Guidelines and Criteria (TR 537)
V. Background Literature (TR 538)

Volume I presents a succinct review of activities and products of the project's first phase. Volume II contains a technical discussion of the project's objectives, methodologies, results, conclusions, and implications for the design of user/operator transactions with battlefield automated systems. Volume III documents analyses of four unique battlefield automated systems selected to represent different stages of system development and different Army functional areas. Volume IV presents provisional guidelines and criteria for the design of transactions. Volume V provides a brief review of selected literature related to guidelines and criteria.

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VOLUME II:

TECHNICAL DISCUSSION

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Human Performance Effectiveness
and Simulation

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Human Factors Technical Area of the Army Research Institute (ARI) is concerned with helping users and operators cope with the ever increasing complexity of the battlefield automated systems by which they acquire, transmit, process, disseminate, and utilize information. Increased system complexity increases demands imposed on the human interacting with the machine. ARI's efforts in this area focus on human performance problems related to interactions with command and control centers, and on issues of system design and development. Research is addressed to such areas as user-oriented systems, software development, information management, staff operations and procedures, decision support, and systems integration and utilization.

An area of special concern in user-oriented systems is the improvement of the user-machine interface. Lacking consistent design principles, current practice results in a fragmented and unsystematic approach to system design, especially where the user/operator-system interaction is concerned. Despite numerous design efforts and the development of extensive system user information over several decades, this information remains widely scattered and relatively undocumented except as it exists within and reflects a particular system. The current effort is dedicated to the development of a comprehensive set of Human Factors guidelines and evaluation criteria for the design of user/operator transactions with battlefield automated systems. These guidelines and criteria are intended to assist proponents and managers of battlefield automated systems at each phase of system development to select the design features and operating procedures of the human-computer interface which best match the requirements and capabilities of anticipated users/operators.

Research in the area of user-oriented systems is conducted as an in-house effort augmented through contracts with uniquely qualified organizations. The present effort was conducted in collaboration with personnel from Synectics Corporation under contract MDA903-80-C-0094. The effort is responsive to requirements of Army Project 2Q263744A793, Human Performance Effectiveness and Simulation, and to special requirements of the U.S. Army Combined Arms Combat Developments Activity (CACDA), Fort Leavenworth, Kansas.

JOSEPH ZEIDNER
Technical Director

DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS VOLUME II: TECHNICAL DISCUSSION

EXECUTIVE SUMMARY

Requirement:

To develop a comprehensive set of human factors guidelines and criteria for the design of user/operator transactions in battlefield automated systems for use by human factors specialists and system proponents, managers, and developers.

Procedure:

To provide data for a baseline functional description of user/operator transactions in battlefield automated systems, user/operator interactions in a series of systems were analyzed using a Transaction Feature Analysis technique. Data were collected during interviews with system experts and reviews of system documentation. Transactions were then compared across systems using a Transaction Compatability Analysis technique. Results of these analyses formed the data base for development of preliminary guidelines and criteria.

Findings:

Results of the system analyses support two conclusions: (1) battlefield automated systems are highly variable on a wide range of attributes related to user/operator transactions; and (2) while examples of good design appear in some of the newer systems, in general battlefield automated systems are characterized by design features that are incompatible with human capabilities and limitations. In addition, review of the human factors literature demonstrated that results of that research are inadequate to support design of good user/operator transactions in automated systems. Data derived through the transaction feature and compatability analyses served the project well as the data base on which the provisional guidelines and criteria are drawn.

Utilization of Findings:

Findings from the analysis of individual systems may be useful to proponents in specifying user/operator requirements for future system evolution. In this project, the findings were incorporated in a data base on human factors requirements which provided the "real world" foundation for development of the provisional guidelines and criteria presented in volume IV of this report. The provisional guidelines and criteria will be utilized as the basis for development of the prototype handbook.

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INTRODUCTION

This document contains a technical discussion of issues considered, project activities, results, and products of the first phase in a three-phase project to develop guidelines and criteria for user/operator transactions with U.S. Army battlefield automated systems.

BACKGROUND

Information has always been a precious commodity on the battlefield, and commanders have always wished for better and faster ways to obtain it. Modern technology is providing increasing numbers of sensors and data collection methods to meet this need. This effort has been so successful that the battlefield of today is an environment rich in information. Indeed, recent years have seen an "information explosion" on the battlefield that may well rival the one in the private sector that has received so much attention. So plentiful has it become that the sheer volume of information pouring into tactical operations centers threatens to overwhelm the capabilities of commanders and their staffs to absorb and interpret it.

The ability to manage the battlefield information explosion--to process information accurately and quickly--might well provide a force multiplier approaching in importance the element of surprise. Unfortunately, this force multiplier will not be achieved merely by assigning more and more personnel to data processing tasks (thereby making fewer personnel available for other urgent duties). Recognizing this fact, the Army has devoted increasing resources to automation. Currently, more than 60 computer-based information processing systems are in production, development, or concept definition for deployment at corps and subordinate echelons. As shown in Figure 1, these automated systems eventually will support most of the Army's battlefield functional areas.

PERSONNEL ISSUES IN BATTLEFIELD AUTOMATION

The proliferation of battlefield automated systems, however, carries with it potentially severe problems. Many of these problems relate to the personnel who will staff them. At least three areas can be identified in

ARMY BATTLEFIELD AUTOMATED SYSTEM CATEGORIZATION

System Life Cycle Status / Battlefield Functional Area	ADMIN	LOG	INTEL	EW	FA	ADA	ENG	COMMO	MVR	A/G
CATEGORY I CONCEPT/ DEFINITION	TAMMIS DISPERS	CSS CONTROL*** CS3 REPLACEMENT OLDED	ASAS TEP AGTELIS TACIES		AASS MLRS FDS	ADEWS SHORAD C2		PACKET RADIO JT10S TYO 16**	MVR CNTL*** ATHS	
CATEGORY II VALIDATION/ DEVELOPMENT		SAMS SAAS SPBS	SOTAS I-TACIES	QUICK FIX TACJAM CAS ECM	RPV TADARS	OAR PATRIOT CSS ECS		TSQ 111** TYC 39 TTC 39 TTC 42*	NBDS PLRS GPS TCS TCT	
CATEGORY III APPROVED PRODUCTION/ INSTALLATION	SIDPERS	CIUS CS3 DAS 3 DS4 SAILS DLOGS MRM DSU/GSU MLS	MAGIIC QUICKLOOK II TRAIL BLAZER GUARDRAIL V SLAR I-TEP		BCS TPQ 36 TPQ 37 PADS TACFIRE MPDG	TSQ 73 ICC/IPCP DST				

* USMC Development
** USAF Development
*** No approved LOA exists

Figure 1. Army Battlefield Automated Systems, Categorized by Status in the System Life Cycle and by Battlefield Functional Area, as of 14 May 1980.

which such problems arise: the human-computer interface, coordination among system developers, and the skill-demand mismatch.

Human-Computer Interface

System developers have tended to regard human beings as highly adaptable to the idiosyncracies of their systems. They have thus felt free to concentrate design and development resources almost exclusively on the computing hardware and on data communication, reduction, and analysis software. Relatively little effort has centered on the human engineering features of the equipment, and even less on the human factors features of the software interface, such as control methods, data entry assistance, display formats, or error handling procedures.

Often, the result has been a human-computer interface that is less than optimal from the user's/operator's point of view. Long lists of data codes impose heavy memory burdens. Densely packed input and output displays strain perceptual abilities. Complex transactions tax cognitive processes. Ambiguous error messages inhibit diagnostic and correction efforts. The consequences of these and other undesirable design features are increased error rates and reductions in data processing rates--and system effectiveness less than required and expected.

Coordination Among System Developers

Recently, system proponents and system developers have begun to show increased awareness of the significance of human characteristics for the design of battlefield automated systems. As will be demonstrated in this report, however, there is no adequate technology readily available to guide their efforts to take those characteristics into account in designing the human-computer software interface. Moreover, Army battlefield automated systems typically are developed independently, with little or no coordination among proponents or developers. Consequently, lessons learned during development of one system seldom find application in other systems. More importantly, configurations and procedures that are quite similar conceptually appear quite different when implemented in various systems. For example, updating a data file is a function common to many battlefield automated systems, whether they support personnel administration, intelligence, maneuver control, or logistics. However, that function may be performed in radically different ways on different systems, depending on design decisions such as:

a. The selection, arrangement, and labeling of function keys.

b. The structures of display formats.

c. The conventions adopted for naming the updating operations.

d. The sequence in which those operations are performed.

The lack of coordination among proponents and developers imposes a special penalty upon users/operators who transfer from one system to another. Normally, of course, increased experience leads to improved performance. But when an experienced user/operator moves from a familiar, well-known system to a new one, very often previously acquired skills do not transfer. Equipment arrangements differ, procedures differ, formats differ, and codes differ. Thus, instead of facilitating performance on the new system, prior experience may actually degrade that performance.

Skill-Demand Mismatch

In turning initially to automation, American business and industry anticipated that computers would reduce personnel skill requirements. As it happened, more often than not, precisely the opposite effect occurred; maximum effectiveness of complex computer technology required greater skills than did the manual methods the technology replaced. The Army has had a similar experience--at a time when its skills pool has been contracting rather than expanding.

The Army confronts an unpleasant prospect. Force levels doubtless will not increase substantially in the near future. At the same time, increasing numbers--and increasing complexity--of battlefield automated systems demand larger numbers of skilled personnel. These facts suggest that a time will come when insufficient personnel with the necessary skills will be available to staff all the systems that have been introduced. Figure 2 illustrates this possibility.

A Possible Solution

The Army Research Institute for the Behavioral and Social Sciences (ARI) has proposed a solution to the problems described above. That solution is to provide guidance for the design of human-computer software interfaces that capitalize on human capabilities and compensate for human limitations. Such guidance would help greatly to optimize the design of the software inter-

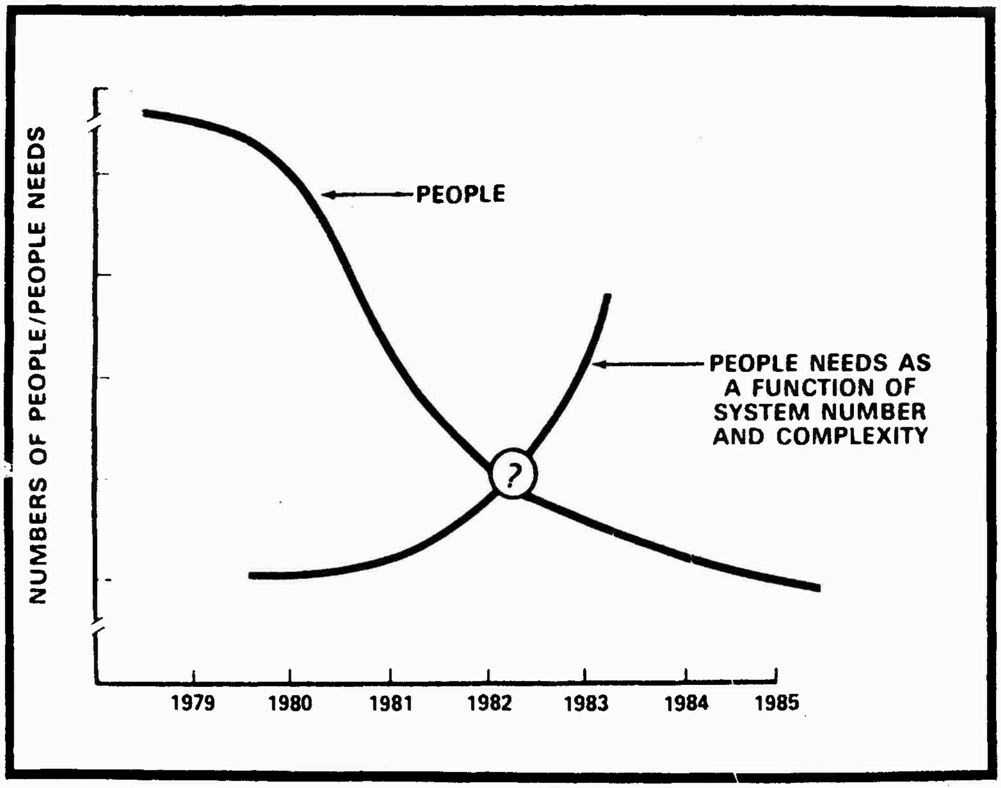

Figure 2. Is there a point where we may have more systems in the acquisition cycle than we have people available to staff and maintain them?

face from the user's/operator's point of view. Consistently applied across systems, it would facilitate coordination among proponents and developers, thereby alleviating the problem of skills transfer among systems. And finally, that guidance would help to make the software interface simpler and easier to use, minimizing the skills-demand mismatch in the process.

PURPOSES OF THE PROJECT

This project has two major purposes:

a. To develop guidelines for the design of user/operator transactions with battlefield automated systems.

b. To develop evaluation criteria for determining the efficacy of transaction design.

Both guidelines and criteria will be written in language and formats suitable for system proponents, developers, and designers as well as for human factors specialists. In addition, guidelines and criteria will be developed for each stage of the system life cycle.

OBJECTIVES

To fulfill these purposes, ARI formulated three principal objectives for the project's initial phase:

a. Analysis of human-computer interactions in battlefield automated systems.

b. Development of provisional guidelines and criteria for the design of user/operator transactions.

c. Identification of critical problems and deficiencies in human-computer interactions.

These objectives are described more fully below.

Analyze Human-Computer Interactions

A "real-world" basis for guideline and criteria development requires knowledge about the characteristics of battlefield automated systems, with particular emphasis on those features that affect user/operator transactions. Therefore, a survey would be conducted of battlefield automated systems. This survey would be conducted in two portions. First, available data on all systems would be reviewed to provide an initial baseline of information. Then, selected systems would be analyzed in greater depth to validate the baseline and provide greater detail regarding user/operator transactions.

Develop Guidelines and Criteria

Guidelines. Working on the baseline established by analysis of actual systems, guidelines must be developed to assist proponents and developers to select interface features best matching the characteristics of anticipated users/operators. This effort could also draw on the information available in the research literature. A fundamental requirement for achieving this objective would be to couch guidelines in terms free of psychological jargon, using language understandable to proponents and developers as well as human factors specialists. Further, guidelines must be explicit and useable. For example, "make displays easy to read" is an unacceptable guideline; it does not indicate specifically how a display can be made easy to read. "Use upper case characters only to begin sentences or proper nouns, or to highlight important words or phrases" would be more appropriate. This statement is not yet proposed as an actual guideline. Nonetheless, it illustrates the specificity

required to tell a designer how to "make displays easy to read." Preliminary guidelines of this type would be a major product of the project's first phase.

Criteria. To provide the means to evaluate transaction feature design from the point of view of the user/operator, criteria are required for each category of design guidelines and for each stage of the system development process. These evaluation criteria must provide objective procedures and techniques for assessing the degree to which candidate software interface features and operating procedures meet the human factors requirements embodied in the guidelines.

Identify Problems

Finally, the first phase of the project would identify the areas of the human-computer software interface in which significant problems and deficiencies exist in the human factors technology. This task would draw upon the results of the first two tasks to identify those areas most critical to successful system performance; to define issues such as error sources and (where possible) frequencies; to specify the implications of problem areas for transaction failure and system failure; and to illustrate problems and deficiencies with examples from actual battlefield automated systems.

APPROACH

To accomplish its objectives, the project involved three major tasks during the first year. The first of these tasks identified and analyzed human-computer interactions in battlefield automated systems. The task began with an initial survey of the general characteristics of these systems, and encompassed as many systems as resources permitted. The final part of the task focused on in-depth analyses of five selected systems. The second task required development of a set of provisional design guidelines and evaluation criteria. These materials will be refined and expanded to provide a prototype proponent/developer handbook later in the project. The third task involved performing an analysis of information gathered during the first task and of guidelines and criteria developed during the second task. This analysis identified critical problem areas and deficiencies in the human-computer software interface that controls user/operator transactions in battlefield automated systems.

ANALYSIS OF HUMAN-COMPUTER INTERACTIONS

INITIAL SURVEY

To identify and analyze human-computer interactions in battlefield automated systems, a survey was undertaken of all such systems. This survey encompassed documentation from the Battlefield Automation Management Plan (BAMP) and the Army Battlefield Interface Concept (ABIC), and a data collection technique devised for this task.

Battlefield Automation Management Plan (BAMP)

The BAMP was administered by the Battlefield Automation Management Directorate (BAMD) of the Combined Arms Combat Developments Activity (CACDA) at Fort Leavenworth, Kansas until CACDA was reorganized in 1979. As originally conceived, the BAMP provided for periodic review of all battlefield automated systems. ARI and Synectics initially believed that a large volume of data had been collected on all or most battlefield automated systems as part of the BAMP review process. These data presumably would include information about the designs and operational characteristics of these systems. Much of this information could be expected to relate to user/operator functions and requirements.

Interviews with former BAMD personnel at Fort Leavenworth, and examination of information available in Alexandria, Virginia revealed that this was not the case. The only materials found were synopses of BAMP system reviews. Table 1 shows the headings of the standard nine-paragraph format of the

Table 1

Format of Synopses of BAMP Reviews of Battlefield Automated Systems

- **Brief System Description**
- **Information Shortfalls**
- **Operational Design Criteria**
- **Life Cycle Cost**
- **Personnel Impact**
- **Commo Impact**
- **System Strengths and Weaknesses**
- **General Remarks**
- **BAMD's Recommendations**
- **References**

synopses. Figure 3 illustrates the form used to record information obtained from the examination of these synopses. The full set of such forms is presented in Appendix A. Figure 3 also illustrates that the BAMP synopses did not focus sufficiently on human factors issues to meet the requirements of this task. For example, they provided no human performance data such as error rates or times required to complete transactions. Further, they provided no data on the types of transactions to be performed by the users/operators in various battlefield automated systems. Finally, human engineering data in the synopses focused exclusively on maintenance issues. Obviously, such issues are critically important to successful system performance. However, they are beyond both the scope and the resources of this project.

Army Battlefield Interface Concept (ABIC)

The major purpose of the ABIC is to define a high level architecture for Army battlefield automated systems. As such, documentation of the concept[1] contains considerable information about these systems. However, this information provides a broad overview of systems, rather than specific, detailed information about particular issues in individual systems. Figure 4 illustrates the form used to record types of unclassified information obtained from ABIC 79 documentation. The full set of data is presented in Appendix B. As with the BAMP, the ABIC 79 did not provide substantitive data on human factors issues of concern to this project, such as transaction types, error rates, or times required to complete transactions.

Transaction Feature Analysis

Given the lack of suitable data from these sources, meeting the project's information needs required development of a special data collection instrument. The result of that effort, the Transaction Feature Analysis technique, met that need. Indeed, the technique became the project's first product, since it also has utility in the system development process, as will be shown later in this report.

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[1]/*Army Battlefield Interface Concept (ABIC)* 79 (U). ACN 47635, Headquarters Department of the Army. Washington, D.C. 20310, 1979. CONFIDENTIAL.

KEY

- O — N/A
- (blank) — No Information
- / — Reference, no substance
- X — Useful, but incomplete
- (solid) — Complete information

INFORMATION TYPE	AGTELIS	CAS ECM	COMFAC	DAS 3	DS 4	GUARDRAIL	IISS	MAGIIC	MULTEWS	NBDS	PADS	QUICKLOOK II	RPV	SAAS	TACELIS	TACJAM	TSQ-73	TRAILBLAZER
• Alternative Data Access Methods	/	/		/	/			/	/	X	X	/	/	/	/			/
Human Engineering																		
• Error Minimization																		
• Self-Test Capability			X						/	X					/			/
• Modular Parts Replacement													/					
• Component Mobility																		
• File Protection From Users							/											
• Control Characteristics																		
• Operator Prompting							/											
Security																		
• Clearances Required	/	/	X		/	/	/	/	/	/	/	/	/	/	/		/	/
• Identification of Users and Terminals							/				/				/			
• Identifier Codes							/											

Figure 3. Format of the data recording form used for examination of BAMP system synopses, illustrating types of information obtained.

BATTLEFIELD AUTOMATED SYSTEMS — ABIC '79

KEY:

● = Stated in ABIC

o = Inferred from ABIC

- = Not Applicable

				INFORMATION TYPE			OPERATOR TYPE(S)					OPERA RA		
SYSTEM ACRONYM OR ABBREVIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	MESSAGE	WEAPON	SENSOR	CLERK	OBS./COL	PROC. OPER.	DATA BASE	ANALYST	E2 - E4	E5 - E6	
MEDMIS	Medical Management Information System	Academy of Health Sciences	1985	●			o			o		o		
MEDPAR	Medical Patient Accounting and Reporting System	Academy of Health Sciences	1985	●			o			o		o		
MEDLOG	Medical Logistics System	Academy of Health Sciences	1985	●			o			o		o		
MEDBLOOD	Whole Blood Management	Academy of Health Sciences	1985	●			o			o		o		
MEDREG	Medical Regulating System	Academy of Health Sciences	1985	●			o			o		o		
SIDPERS	Standard Installation/ Division Personnel System	MILPERCEN	1972	●			o		o	o		o	o	

Figure 4. Format of Data Recording Form Used in Examination of ABIC 79, Illustrating Types of Information obtained.

The Transaction Feature Analysis technique consists of a six-step narrative description of a system design feature and its effect on system performance. The headings of the six steps are shown in Table 2, and described in detail below.

Table 2

Format of the Transaction Feature Analysis Technique

- TRANSACTION FEATURE
- DESCRIPTION
- BEHAVIORAL IMPLICATION
- TRANSACTIONAL IMPLICATION
- CONSEQUENCE(s)
- RECOMMENDED RESOLUTION

Transaction Feature. The transaction feature is a description of a generalized designator of a class of transactions. It provides a simple definition of the transaction type. For example:

Constraints in updating multivalued fields.

Description. The description explains how the transaction feature works and what it does, in simple operational terms. For example:

Many of the fields in the data files are multivalued fields. During updating functions, the user/operator has the capability to add new items to these fields, or to change or delete existing items in a field. If the user/operator wishes to delete only a portion of a field, but neglects to specify the particular items to be deleted, then execution of a change or delete command will delete all items in that field.

Behavioral Implications. Behavioral implications involve the transaction features' impact on the user/operator. This section describes what the user/operator must do (and must not do) to complete the transaction successfully. It also describes the demands the feature imposes on the user/operator in terms of memory burden, skill requirements, error likelihood, and other performance issues. For example:

In updating only a portion of a data field, the user/operator must remember to specify precisely the items

to be changed or deleted. This requirement imposes an excessive memory burden on the user/operator, and provides an unnecessary source of performance error.

Transactional Implications. In contrast to the behavioral implications, this section describes the feature's effect on system operations. This effect is described in operational terms such as the system's capability to detect errors or the time required to complete transactions. For example:

Complete data removal from an entire field is a legal operation. The system therefore cannot determine when such removal constitutes an error.

Consequences of the Problem. In this step, the transaction feature's impact on the system's effectiveness is described in operational terms. For example:

Data base integrity will be eroded by inadvertent loss of relevant data items. Reports may lack significant or even vital information. The commander's picture of the battlefield may be distorted.

Recommended Resolution. Finally, specific pragmatic actions are suggested to improve the performance of user/operator transactions with the computer. For example:

Modify system software to require the user/operator to enter a positive indication of his/her intention to delete an entire data field. For example, require the user/operator to enter "DELETE (field name) ALL" when the entire field is to be deleted.

Alternatively, if a feature is described that cannot currently be corrected because of, say, cost considerations, the recommended resolution might apply to future versions of the system or to similar systems presently under development. The analysis merely describes the recommended resolution, of course, since development personnel are in the best position to evaluate the tradeoffs inherent in the situation.

Using the Transaction Feature Analysis technique, a survey was conducted of nine Army battlefield automated systems, two USMC systems having significant features in common with Army systems, and a Rand Corporation system developed for intelligence applications (Table 3). Observations of

Table 3

Systems Surveyed with Transaction Feature Analysis Technique

TACFIRE	IISS
TOS[2]	BCS
TCT	MAGIS (USMC)
DS4 AUTO RUN BOOK	SDA (USMC)
DLDED	ISIS (RAND)
PHOENIX AUTO RUN BOOK	DAS3

these systems were recorded on a data collection form designed for this purpose (Figure 5). Examples of brief reports resulting from this surey are presented in Appendix C. These examples are included for illustration only; findings of the survey were integrated with those of analyses described below.

ANALYSES OF SELECTED SYSTEMS

Validation of the data obtained from the survey required more detailed human factors-oriented analysis of the user-computer software interface in battlefield automated systems. Such analyses also would broaden the baseline of information about user/operator transactions initially established by the survey. The time and resources available to the project precluded analysis of a large number of systems, however, so a sample was selected from the systems listed in Figure 1.

Selection Criteria

Two criteria governed the selection of systems for analysis:

a. A system had to be chosen from each of the stages of the system life cycle: concept definition, validation/development, and production/deployment.

b. The selected systems had to represent different Army battlefield functional areas.

The three systems initially selected met these criteria, and were accessible for analysis:

TRANSACTION FEATURE ANALYSIS FORM

SOURCE ____________ ANALYST ________ DATE ________

BAS ____________ INTERFACE ____________

FUNCTION ____________ TASK ____________

OPERATION ____________ TRANSACTION TYPE ____________

TRANSACTION FEATURE

DESCRIPTION

BEHAVIORAL IMPLICATION

TRANSACTION FEATURE ANALYSIS FORM (CONTINUED)

TRANSACTIONAL IMPLICATION

CONSEQUENCES OF THE PROBLEM

RECOMMENDED RESOLUTION

Figure 5. Data Collection Form Used to Record Observations of Battlefield Automated Systems.

a. The Division Level Data Entry Device (DLDED) is presently in concept development, and is designed for use both in personnel administration and logistics.

b. The Tactical Computer Terminal (TCT), a system currently in validation/development, will support the maneuver control area.

c. The Tactical Fire Direction System (TACFIRE) is in production/deployment, and is a field artillery system.

After these systems were selected, two additional systems were included in the sample.

The DS4 Automated Run Book was added by invitation from the system's developers. The Run Book will provide a software interface between functional supply personnel and the DS4 supply data processing software package that runs on the DAS 3 computer.

The Intelligence Information Subsystem (IISS) was added to the sample as an additional task to the contract. The IISS is a system currently in validation/development for the intelligence functional area. Including these two systems broadened the analysis sample and also provided additional data for the baseline on user/operator transactions.

Data Collection

Data were gathered by two principal methods. First, ARI and Synectics personnel interviewed subject matter experts and/or developer personnel at Fort Benjamin Harrison, Fort Lee, and Fort Belvoir (DLDED and DS4 Automated Run Book); at Forth Monmouth and the MELPAR building near Washington, D.C. (TCS/TCT); at Fort Sill, Oklahoma (TACFIRE); and in USAREUR (IISS). Where possible, visits to installations included observations of the system. Second, they studied available documentation to extract information about system design features and operating procedures that would affect user/operator transactions with the system's computer. During both interviews with subject matter experts and studies of system documentation, extensive use was made of the Transaction Feature Analysis technique described above.

Classification Scheme

During both the initial survey and subsequent more detailed analyses of systems, observations were recorded on a wide range of design features that

would affect user/operator transactions. Comparing these transaction features both within a single system and among different systems was necessary to permit identification of problems and deficiencies that are common to systems as well as those unique to a particular system. Such comparisons would be greatly facilitated by some kind of classification scheme that would organize observations in a coherent and consistent manner.

Existing structures. The literature reporting research on the human-computer interface contains several such organizing structures. Engle and Granda[1], Ramsey and Atwood[2], and Smith[3] are among those who have devised schemes to classify their own design recommendations. Inspection of these schemes shows that, while there are common features, none of the structures found in the literature is consistent with the others. Doubtless, consistency will emerge in this relatively new field of research as work continues. Doubtless also, different levels of taxonomy will be developed to meet differing requirements. In the meantime, the existing structures appeared inappropriate for this project because they were judged to be too detailed or too psychologically oriented for its purpose.

Structure adopted for this project. Analysis of data collected early in the survey yielded a tentative pattern of transaction features. As data collection and analysis continued, the initial structure was modified, resulting finally in the categories shown in Table 4. This scheme is not entirely satis-

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1/Engle, S.E. and Granda, R.E. *Guidelines for man/display interfaces*. Technical Report TR 00.2720. Poughkeepsie, New York: IBM Poughkeepsie Laboratory, December 1975.

2/Ramsey, H.R. and Atwood, M.E. *Human factors in computer systems: A review of the literature*. Technical Report SAI-79-111-DEN. Englewood, California: Science Applications, Inc., September 1979.

3/Smith, S.D. *Man-machine interface (MMI) requirements definition and design guidelines: A progress report*. Technical Report MTR-8134: The Mitre Corporation, Bedford, Massachusetts, September 1980.

Table 4

Categories of Design Features Affecting User/Operator Transactions with Battlefield Automated Systems

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1. CONTROL METHODS
    - 1.1 Command Languages
    - 1.2 Menus
    - 1.3 Function Keys
    - 1.4 Hybrid Methods
    - 1.5 Prompts/HELPS
2. DISPLAY FORMAT
    - 2.1 Fixed Alphanumeric Displays
    - 2.2 Variable-Length Alphanumeric Displays
    - 2.3 Graphic Displays
    - 2.4 Highlighting
3. DATA ENTRY AND HANDLING
    - 3.1 Information on Legal Entries
    - 3.2 Unburdening of Input
    - 3.3 Interrupts and Work Recovery
    - 3.4 Manipulating Stored Data
4. MESSAGE COMPOSITION AIDS
    - 4.1 System Design Features
    - 4.2 Format for Alphanumeric Messages
    - 4.3 Graphic Messages
5. DATA RETRIEVAL ASSISTANCE
    - 5.1 Query Method
    - 5.2 Query Structure
6. GLOSSARIES
    - 6.1 Standard Terms
    - 6.2 Character Sets and Labels
    - 6.3 Glossary Availability and Use
    - 6.4 Abbreviation and Coding
7. ERROR HANDLING
    - 7.1 Prevention
    - 7.2 Detection
    - 7.3 Feedback
    - 7.4 Correction/Recovery
8. USER/OPERATOR CONFIGURATION
    - 8.1 Operator(s) Only
    - 8.2 Operator(s) and User(s)
    - 8.3 Combined User/Operator
    - 8.4 User and Operator Chains

---

factory, since transaction features sometimes are difficult to assign to one category as opposed to another. Probably, it will be modified as work proceeds on the prototype guideline and criteria handbook during the second phase of the project. Even so, the current list of transaction features in Table 4 provides a convenient structure for organizing the observations recorded during the survey and analyses of systems.

Presentation of Findings

For each system analyzed in detail, a separate report was prepared. Each report describes general hardware and software features of the system that relate to the human-computer interface. The remainder of the report describes the analysis of specific system software interface features that affect the performance of user/operator transactions. Transaction feature analyses of these specific features were summarized according to the categories in Table 4, and the feature analyses themselves are provided in an Appendix to the report.

The separate reports do not consolidate information gathered for the various systems. Rather, each is a separate, stand-alone entity, and is bound separately in Volume III of the Final Report. This method of presentation permits persons who are particularly interested in the analysis of a specific system to access the relevant report conveniently. Integration of the results and discussion of their relevance to design guidelines and evaluation criteria begin immediately below.

RESULTS

Results of the survey and analysis of systems are discussed in two parts: a general discussion of differences in common features; and a more detailed discussion of specific transaction features, organized according to Table 4.

General Results

The systems examined during this task seem to belong roughly to two classes, designated "Class I" and "Class II" for convenience of expression. Table 5 repeats the systems listed earlier in Table 3, this time broken down into the two classes. These classes are immediately distinguishable on at least

Table 5

Systems Examined During First Phase of This Project, Broken Down by Classes

CLASS I	CLASS II
TACFIRE	DS4 Auto Run Book
TOS[2]	DLDED
TCT	PHOENIX Auto Run Book
IISS	SDA
BCS	DAS 3
MAGIS	
ISIS	

one militarily meaningful criterion. That is, Class I systems will provide data processing services to the combat and combat support branches. Class II systems, on the other hand, are combat service support systems. The two groups differ on other characteristics, however, that are more important from the perspective of this project. These differences include at least the following:

a. User/operator interaction

1. In Class I systems, interaction among users and operators ranges from limited in IISS to moderate in MAGIS to extensive in TACFIRE. Much of this interaction is job-related, as when fire requests are sent from the Forward Observer to the Artillery Control Console Operator, or when an intelligence analyst passes processed information from one terminal to another.

2. In Class II systems, there is very little interaction among users and operators, and even that is confined largely to matters of system operations, as when the user asks for a magnetic tape to be mounted or for a reinitialization following a nonrecoverable situation.

b. Data currency

1. In Class I systems, certain classes of information are highly time-sensitive. For example, information about the location of targets may be valid only for minutes; information about enemy movements may be valid no longer than a few hours.

2. In Class II systems, few information items are so ephemeral. For example, the fact of a lost tank is valid until that tank is replaced, no matter how long it takes. The same is true of personnel, of course; specialists in particular may be difficult to replace.

c. Data base access/manipulation

1. In Class I systems, users access data bases directly and interactively. Thus, an update entry changes a data base as soon as validity and error checking are completed. Also, users can query the data base directly.

2. In Class II systems, users interact directly only with an interface program. That is, a program (or even a separate small computer system) is used interactively to build up an input file for entry into another program, perhaps on a different computer. Similarly, queries are constructed by the interface program, then passed on to the data processing system. In Class II systems, therefore, users interact with data bases indirectly.[1]

The differences in system characteristics that yield classifications as described above have implications for the development of guidelines and criteria. For example, Class I systems require guidelines for the design of user-to-user message, and of procedures for transmitting the contents of a screen display or data file from one user terminal to another. The time-sensitivity of certain information types probably has its greatest implications for the design of communication links, which are beyond the scope of this project. Nonetheless, error prevention techniques are especially important with such types of data, and guidelines must reflect this fact. The "distance" between the user and the data base also has implications for error prevention. Thus, when the user interacts with the data base directly, error feedback can

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[1]/There are plans to make future generations of these systems more directly interactive, however.

be provided immediately for any detectable error. When the interaction is less direct, on the other hand, only certain errors can be detected immediately by the interface system since it contains little or none of the data base. Consequently, it lacks much of the legal value information required for error and validity checks. The result is that error feedback to the user is delayed for many types of errors until after the larger system has processed the input stream. This delayed feedback may require more diagnostic information to be as effective as immediate feedback because it reaches the user without the contextual cues available during the terminal session in which the error occurred.

Differences in common features. Battlefield automated systems share many common features. They all include some kind of keyboard, for example, and some kind of display device. Many of the operations they perform are functionally similar, such as calling up information from a file, and transmitting data from the display to the CPU for processing. Yet, most of these common features differ from one system to another. Figure 6 illustrates some of these differences in general design features among five systems drawn from the larger sample. The figure shows that the systems differ substantially in many respects, as for example in the command types they employ and the methods they use to enter commands.

When examined in closer detail, differences among systems become even more apparent. Figure 7 shows nine different types of transactions and the methods used to perform them on the five systems. Notice in the figure that no transaction is performed the same way on any system, even if only the Army systems are considered (i.e., TACFIRE, TCS, and IISS. Even when systems appear to use the same method for the same or similar transaction, these similarities disappear under closer inspection. For example, Figure 7 shows that both TACFIRE and TCS use a fixed function key to display the first part (or page) of the next block (or message) to be worked on. They even use the same generic terms--but the labels are spelled differently. Figure 8 shows the same pattern of differences in additional transaction types.

The use of symbols also is inconsistent from one system to the next. Figure 9 shows how nine different non-alphabetic symbols are used in the five systems drawn from the larger sample. Only two of these symbols are used in

GENERAL DESIGN FEATURES	SYSTEMS				
	TACFIRE	TCS	I^2S^2	MAGIIS	ISIS
COMMAND TYPE	o Menus o Preformatted messages o Hardware	o Menus o Preformatted messages o Hardware	o Menus o Command language o Hardware	o Menus o Command language o Hardware	o Command language
COMMAND ENTRY METHOD	o Function keys o Message entries	o Keyboard o Function keys o Message entries	o Light pen o Function keys o Keyboard	o Function keys o Keyboard	o Keyboard
AVAILABILITY OF HELPS/ USER AIDS	o None	o 2 levels of support	o HELP from GIM menu o Some displays have integral HELPS	o Tutorial messages	
SHOEBOX FILES	o No	o Staff working files	o Yes	o Yes	o Yes
TYPE OF SYSTEM	ARTY C^2	C^2	Intel	Intel	File Handling
APPLICATION ENVIRONMENT	Division & below	Casa	Theater	Division	
INTENDED USERS	Higher-level artillery specialists	CDR; G2 & G3 staff officers	CDR, G2 Intel analysts	CDR, G2, Intel analysts	
INTENDED OPERATORS	Lower-level artillery specialists	G2 & G3 staff Enlisted personnel	Intel analysts	Intel analysts	
USER-DEFINED COMMANDS	o None	o None	o Report formats built in GIM-11 o Macro language	o None	o Yes
USER-DEFINED INPUT CODES	o None	o None	o Report formats built in GIM-11 o Macro language	o None	o Yes

Figure 6. Differences among general design features of selected battlefield automated systems.

TRANSACTION TYPE	SYSTEMS				
	TACFIRE	TCS	I^2S^2	MAGIIS	IIS
Display the master menu	Shown on the SPA message format matrix	FFK FRMT DIR	FFK MASTER MENU	PFK 21	CL SHOW THE TEMPLATES
Acknowledge receipt of a message	FFK ACK	FFKs ACK or NAK	FFK ACK	Automatic Indicator MSG ACK'D	N/A
Display first part of next block of work to be done	FFK CYCLE MESSAGES	FFK CYCLE MSG	VFK NEXT ACT	PFK 30 CL GET....... SELECT....	CL SHOW FILE CALLED DISPLAY FILE CALLED..
Display next part of block of work being done	FFK PAGE	FFK PAGE	FFK NEXT PAGE	PFKs 31 34 39 CL Page F	CR (Carriage Return)
Delete a line/portion of a line	N/A	FFK + PFK TEST EDIT + R	FFKs LINE DEL or WORD DEL	FFK LINE ERASE CL DELETE.... AFTER.....	CL OR REMOVE..... KEEP.......
Clear selected part of screen (display)	FFK ERASE	FFK CLEAR SCRN	VFK CLEAR SA	FFK + FFK ERASE ENABLE + PAGE ERASE	CL PURGE......
Print the screen (display)	FFK PRINT	FFK PRINT	VFK PRINT PAGE	PFK 16 CL PRINT 1	CL DISPLAY..... PRINT.......
Input from display to CPU for processing	FFKs RD COMPTR ACTION or C/ED COMPTR ACTION	FFK ENTER	FFK SEND	PFKs 32 or 33 CL EXECUTE......	CL PERFORM...... WHILE........
Transfer from screen to other equipment (or screen)	FFKs RD XMIT or XMIT	FFK XMIT	Master Menu Selection, e.g. - User Message - Plot - Teletype	FFK XMIT CL TRANSFER TO.....	CL COPY......

FFK = Fixed Function Key
VFK = Variable Function Key
PFK = Programmable Function Key
CL = Command Language statement

Figure 7. Differences in execution of selected transaction types in battlefield automated systems.

TRANSACTION TYPE	SYSTEMS				
	TACFIRE	TCS	[illegible]	[illegible]	[illegible]
Place current display contents in storage	FFKs REPL or SAVE	FFK SAVE RST	CL EXECUTE...	CL STORE...	CL SAVE...INTO...
Print a log of recent transactions	N/R	FFK PRINT LOG	N/R	CL COMMAND...	N/R
Purge excess or unneeded file	Preformatted message	Preformatted message	CL DELETE...FILE...	CL PURGE...	CL REMOVE...
Print an entire file or selected pages	FFK PRINT	FFK PRINT	VFKs PRINT DISP or PRINT PAGE	CL PRINT...	CL DISPLAY... OR PRINT...USING...
Create a new file	N/R	N/R	CL CREATE...	CL CREATE...	CL SAVE...INTO...FILE
Select an input format	SPA message format matrix	Menu selection procedure	VFKs SELECT FORM or SELECT GIN	Select from QURP menu	CL SHOW FORMAT CALLED.
Copy data from one screen area to another	FFK TRANSFER TO EDIT	FFK XFER TO EDIT	FFK COPY	FFK DUP	N/R
Plot previously processed data	SPA message format matrix	FFK GRAPHIC	CL PLOT...	PFK 20	N/R

FFK = Fixed Function Key
VFK = Variable Function Key
PFK = Programmable Function Key
CL = Command language statement

Figure 8. Differences in execution of additional transaction types in battlefield automated systems.

NON-ALPHABETICAL SYMBOLS	SYSTEMS				
	TACFIRE	TCS	[illegible]	[illegible]	[illegible]
:	• Follows field label	• Follows field label		• Separate hr/min/sec • Cursor 2 • Separates mnemonics • Command prefix	
;	• Precedes field label	• Precedes field label		• Separates between elements in analyst utilities	
*	• Multi-valued field delimiter	• Multi-valued field delimiter	• Arithmetic operator (multiply)	• Prefix to all commands in display handler	• Delimiter in display file
/	• Multi-valued field delimiter (unlike code characteristics)	• Multi-valued field delimiter (unlike code characteristics)	• Field delimiter • Arithmetic operator (divide)	• Separate mm/day/yr • Prefix to all commands in executive	• Delimiter in display file
.	• Multi-valued field delimiter (like code characteristics)	• Separator Same as TACFIRE		• Separator for data recording file • Indicates truncation of data value	• Indicate space in display format spec. • Return to primary object in logical expression
#		(Same as above)	• Statement delimiter	• Indication of continuation of line	
$				• End of data record record	• Specifies data constant
-	Indicates spaces not used for data entry	Indicates spaces not used for data entry	• Arithmetic operator (subtraction)		• Arithmetic operator (subtraction)
'			• Value enclosure	• Bracket values containing leading blank • Encloses literal strings	• Encloses literal strings • When on different lines, a new line in [illegible]

Figure 9. Differences in non-alphabetic symbols used in battlefield automated systems.

all five, or even in the three Army systems. And, even in those Army systems, the symbols are not used consistently.

Figure 10 shows examples of the use of codes to express Boolean/relational/logical operations. Although they are not provided in all systems (TACFIRE and the DS4 Automated Run Book are examples), these operations typically are used to define subsets of information. In reviewing the status of units following a battle, for example, one might wish to obtain the unit IDs for "all companies that suffered casualties greater than 20% of authorized strength." Erroneous use of Boolean/relational/logical operators can produce misleading results or undesired information. For instance, entering "< 20%" instead of "> 20%" could generate an output exactly opposite to that desired in the above example. As another example, misusing Boolean/relational/logical operators has led to line printers being tied up for excessive periods of time because a user/operator did not define properly an appropriately small subset of information to be printed out from a data base.

BOOLEAN / RELATIONAL / LOGICAL OPERATION	SYSTEMS				
	TACFIRE	TCS	I^2S^2	MABS	ISIS
EQUALS	?	EQ	EQ	EQ	= ; IS
IS NOT EQUAL TO	?	?	NE	NE; NQ	IS NOT
LESS THAN	?	LT	LT	LT; LS	<
LESS THAN OR EQUAL TO	?	?	LE	LE; LQ	?
GREATER THAN	?	GT	GT	GT; GR	>
GREATER THAN OR EQUAL TO	?	?	GE	GE; GQ	?
OR	?	?	OR	OR	OR
AND	?	?	AND	AND	AND
NOR	?	?	?	?	?
NAND	?	?	?	?	?
NOT	?	?	NOT	?	?
IF...THEN...ELSE...	?	?	IF...THEN...ELSE...	?	?

Figure 10. Symbols used for Boolean/relational/logical operators in battlefield automated systems.

User/operator terminal devices provide another example of differences among battlefield automated systems. The center of Figure 11 shows a representation of a standard office typewriter keyboard. Obstensibly, many systems employ the same keyboard. As Figure 11 shows, however, different systems use different configurations of keys for non-alphanumeric characters.

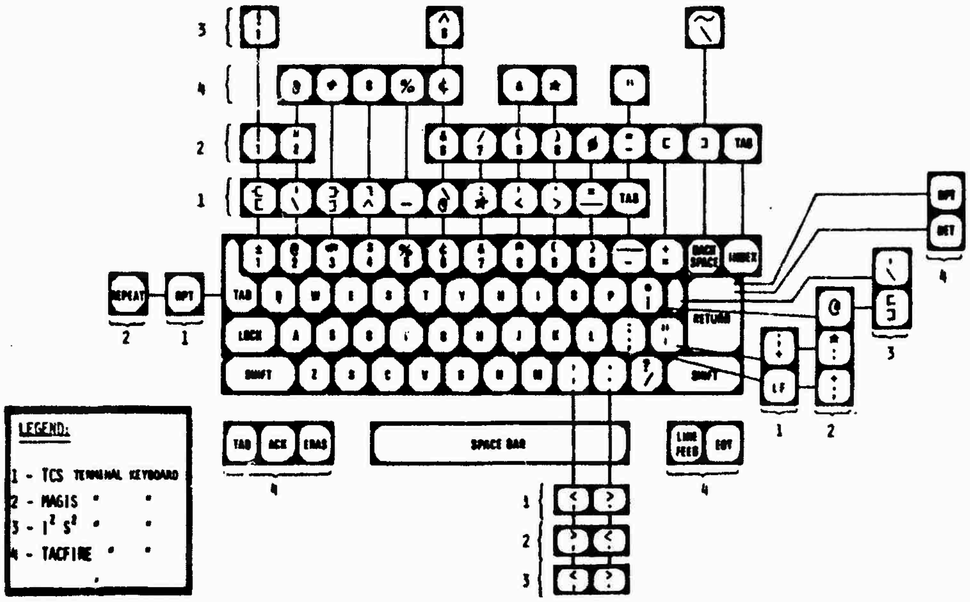

Figure 11. The standard office keyboard configuration and variations found in selected battlefield automated systems.

Even within a given system, differences in keyboard configuration are often found between different terminals. Figure 12, for example shows the configurations of the keyboards on two TACFIRE terminals, the Digital Message Device (DMD) and the Artillery Control Console (ACC). Notice that on the DMD, the alphanumeric keys are arranged in alphabetical order, with non-alphabetic keys on the bottom row. By contrast, the ACC has a modified QWERTY (or office typewriter) keyboard. Additionally, the numeric keys on the DMD are arranged in the standard desk calculator format; meanwhile, the numeric keys on the ACC are arranged in the format of a telephone keyset.

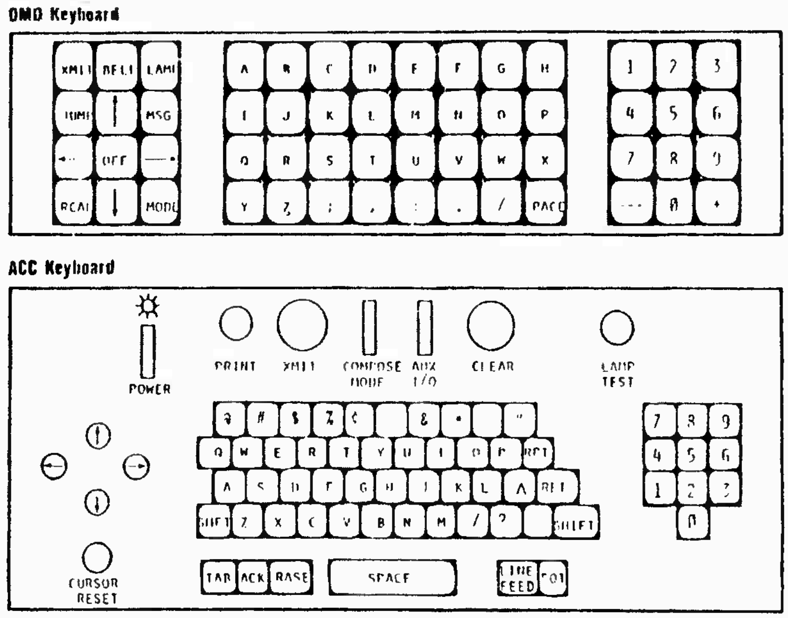

Figure 12. Two keyboard configurations used in TACFIRE.

System differences by no means are confined to hardware configurations. For example, Figure 6 shows that TACFIRE, TCS, and IISS all include menus in their command types. This apparent similarity disappears when the menus themselves are inspected (Figure 13). The figure shows that differences in menu display configurations are as great as those in hardware configurations. Indeed, methods for selecting menu options also differ: in TACFIRE, the cursor is moved to the space to the right of the desired option and a selection character is inserted; in IISS, the user touches the desired option with a light pen; and in TCS, the user enters the line number of the selection.

The implications of differences among systems such as those described above will be discussed later in this report. The next section discusses particular transaction features in more detail.

1. Control Methods

1.1 Command Language. Command languages are not generally used in battlefield automated systems. TACFIRE and TCT, for example, do not provide user/operator access to a command language at all. Evidently, no decision has been

```
        ; P :  ; S B :  /  /  /    /      ; C : U N   ;
S Y S ; S B T ; E D I T :  ; P R I N T :  ; D E L E T E :   ;
I 1 :    ; L 1 :  /  /  /    /     ; P 1 :    ; D 1 :   ;
I 2 :    ; L 2 :  /  /  /    /     ; P 2 :    ; D 2 :   ;
I 3 :    ; L 3 :  /  /  /    /     ; F 3 :    ; D 3 :   ;
I 4 :    ; L 4 :  /  /  /    /     ; P 4 :    ; D 4 :   ;
I S :    ; L S :  /  /  /    /     ; P S :    ; D 5 :   ;
```

TACFIRE PREFORMATTED MESSAGE INCLUDING EDIT, PRINT, AND DELETE MENU

```
CLASSIFICATION                       FOR TRAINING DNLY
                          GIM MENU

ALL DATA BASES:         ANALYSIS:           INPUT:
   GIM LANGUAGE        EUNITS            IUNITS     UUNITS
   UTUGEO              AUITF             IAIRF      UAIRF
   REPDRTW             ARFLDF   ACTF     ARFLDF     ACTF
   BOT                 PERSNF   PPTGT    PERSNF     PPTGT
MISCELLANEDUS:         RIIF     RWY      RIIF       RWY
   NEXT ACTIVITY       INSTF             INSTF
   EXTRACT PILDT DATA

ANALYSIS.  INPUT AND MISCELLANEOUS CDLUMNS FOR USE
           WITH TACCB DATABASE ONLY!
```

I^2S^2 GIM MENU

```
    DATA ENTRY FORMAT MENU SELECTION
1.  SYSTEM INITIALIZATION
2.  CHANNEL INITIALIZATION
3.  LOCAL USER INITIALIZATION
4.  LINK INITIALIZATIDN
5.  SUBSCRIBER INITIALIZATIDN
6.  COMMUNICATION ERRDR THRESHDLDS
7.  INITIALIZATION AUTHORIZATION
8.  ANTI-JAM MATRIX
SELECT ( )
```

TCS SYSTEM INITIALIZATION MENU

Figure 13. Menu display configurations in three Army battlefield automated systems.

made for DLDED in regard to a command language. Users/operators of the DS4 Automated Run Book will have access to the DAS 3 GCOS command language, but apparently it will be used only for special operations, and then infrequently. The IISS offers the richest command language capability of all the systems encountered in this project. Depending on the type of control transaction to be performed, IISS users may choose among:

a. The Honeywell TSS Command/Monitor language.

b. The Honeywell H-6000 Batch Job Control Language.

c. Software switches (i.e., codes) which perform as a kind of command language.

d. The GIM-II language.

Of these, GIM-II is undoubtedly the most important. A user/operator who possesses a detailed knowledge of this language can use it to perform virtually any IISS function quickly and efficiently.

Command languages are extremely powerful and highly flexible methods for controlling the sequences of computer processes. Their syntax and structure

are defined precisely; they are designed to be as concise as possible, with heavy use of brief abbreviations and codes. These attributes eliminate the ambiguity, redundancy, and lack of precision characteristic
Employed by a skilled and experienced user/operator, command languages permit very rapid and efficient interaction with the computer. This becomes especially true when the command language is combined with a "command macro" capability.

Command macros basically are computer programs written in command language instead of more conventional programming languages such as COBOL or FORTRAN. They are useful whenever a user/operator frequently enters the same sequence of command verbs and parameters to perform a routine function. If the system includes a command macro capability, the user/operator writes the commands as a command macro, assigns it a name, and saves it in a personal file. Then, when the user/operator needs to perform the function, merely entering the name of the command macro causes the function to be executed.

The same attributes of command languages and macros that make them such powerful tools for skilled, experienced users/operators, however, tend to make them very difficult for unskilled, inexperienced, unsophisticated personnel. Their syntax and structure, so different from those of normal language, appear unnatural and even unhuman to the unskilled. The properties of verbs, connectors, qualifiers, and literals that give command languages their power and flexibility also introduce subtle traps for the unwary. Abbreviations and codes mystify the unitiated, forcing heavy reliance on off-line sources with attendant costs in time and frustration.

Additionally, the precision and concise structure of command languages make many of them extremely inflexible in terms of entry requirements. Words, abbreviations, and codes must be spelled correctly. The format of each command statement must be followed rigidly, with parameters arranged in their proper sequence and appropriate delimiters placed in their proper positions. Given these factors, unsophisticated users often become confused and commit any of a number of errors, including:

a. Simple typographical errors.

b. Leaving out required parameters.

c. Entering extraneous parameters.

d. Arranging parameters in the wrong order.

e. Entering incompatible parameters.

At best, such errors result in error messages and the necessity to re-enter command statements, with consequent delays in data processing and user/operator frustration. At worst, erroneous data could be entered into data bases; data processing functions could be executed improperly, unnecessarily, or prematurely; or data files could be destroyed.

1.2 Menus. Menus are used in one form or another in all the battlefield automated systems encountered in this project. TACFIRE makes only limited use of them, and does not use them well from the user's/operator's point of view. Recall that in Figure 13 menu options were embedded in a preformatted message. Another type of menu is the format directory message, listing the message format types in each message category. In both cases, menu options are listed horizontally. This imposes a burden on the user/operator because scanning is more difficult when trying to locate the desired option quickly. A more serious problem occurs in actually designating an option. To do so, the user/operator positons the cursor to the element field of the data element. Depending on the particular message and option, the user/operator then enters an "X," an "A" a "Y," and "S," or some other character. Some of these data elements permit more than one legal entry (such as "A" for "all" and other characters for other options). For most, however, only one character is legal. The legal character differs from one data element field to another: one element field requires an "X," another requires an "A," and so on. The system provides no on-line assistance indicating which letter is required for a given element field. Thus, the user/operator must know which letter will satisfy the requirement of each menu data element. This necessity imposes an excessive memory burden on the user/operator and creates a highly error-prone situation for no defensible purpose.

The TCT uses menus extensively. The message format type is selected from a format menu (Figure 14) which is accessed by pressing the FRMT DIR (format directory) fixed function key. The message format is displayed on the upper portion of the display screen. As the cursor moves from data field to data field, a prompt is provided for some fields and a menu of appropriate responses for other fields appears in the prompt area of the screen. Even non-numeric data are entered by inputting numeric codes.

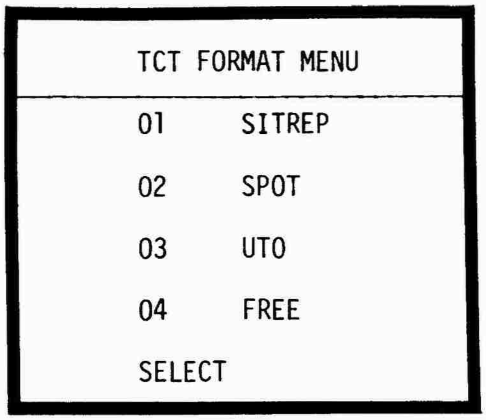

Figure 14. The TCT format menu.

For example, suppose the user/operator selects the SITREP message format by entering a "1" (the leading zero need not be entered) and then pressing the "ENTER" key. Figure 15 shows the SITREP format after the first data field has been filled (see 1.5 Prompts/HELPS).

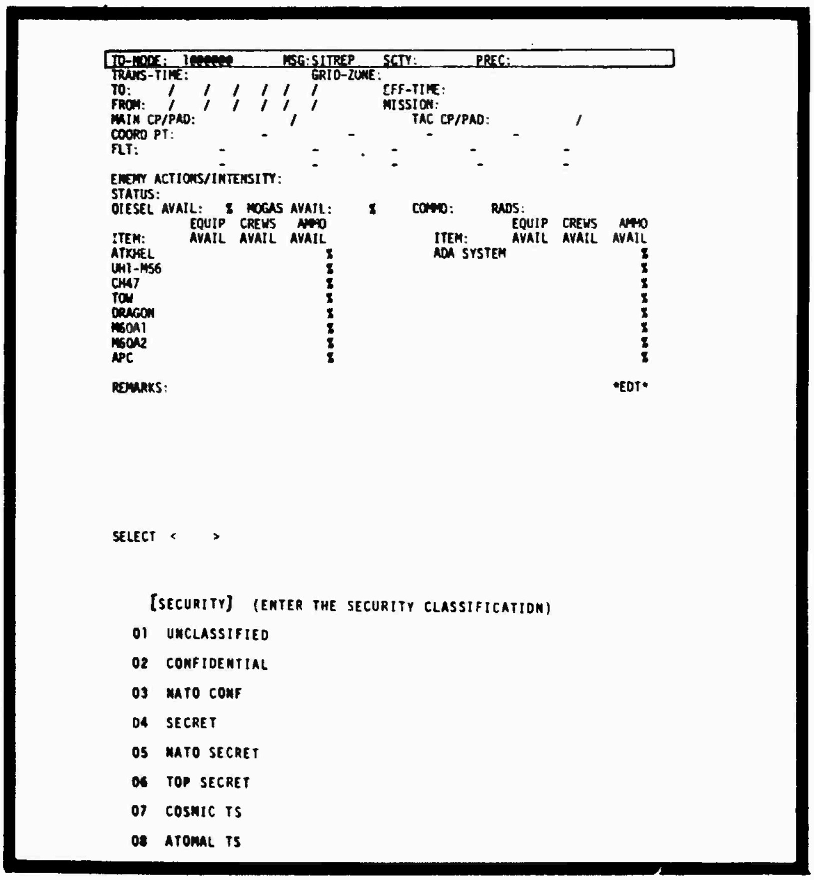

Figure 15. The TCT SITREP message format with menu for second data field at bottom of screen.

The message format itself appears in the upper portion of the screen, called the Message Display Area. Below that, user/operator selections will appear in the "SELECT < >" area. Near the bottom of the frame is the Prompt Display Area. When the list of legal values for a data field is short, they will be displayed in a menu in this area, as illustrated in the figure. The user enters the appropriate number to indicate the desired option, and presses the "ENTER" key. The selected information item (e.g., "UNCLASSIFIED") appears in the message format immediately. The use of menus in this manner relieves the user/operator of the necessity to remember the list of legal values, or to refer to off-line sources. This practice should thus help to reduce errors and increase processing efficiency. One minor problem, however, was observed in TCT menu usage. At some points in the initialization process, the TCT display menu options for communication channel characteristics that are illegal, given the characteristics selected in previous menus. For example, if "NRZ" is the selected modulation, then only 1200, 2400, 4800, and 9600 are valid data rates. However, the system presents all 11 of the available data rates, thereby forcing the user/operator to remember, for each successive menu, which options remain valid, given earlier menu selections. This requirement imposes an unnecessary memory burden on the user/operator.

In contrast to TCT, the IISS does not use menus extensively. Indeed, there are only two pure menus in the system, a master menu (Figure 16 GIM-II language menu (Figure 17). Both the MASTER MENU and the GIM MENU indicate available options by listing brief terms or abbreviations for those options. The user/operator must remember the meaning of the terse option descriptions. This poses unnecessary memory loading on the users/operators of the system. Failing to recall the meaning of the terse prompts may result in the user/operator selecting an inappropriate item from the menus, or in the necessity for looking up the meanings of prompts in reference documentation. Additionally, to select options from either the MASTER MENU or the GIM-II MENU, the IISS user places the light pen tip over any portion of the term or phase denoting the desired option. The terminal "beeps" to indicate that the light pen is positioned over a valid entry. The user must then press the SEND key to enter the selection into the IISS system. If the user is selecting the GIM-II MENU from the MASTER MENU, the light pen is used for two selections in a row; otherwise the user enters commands and data using the SU 1652 terminal keyboard. This requires the user to look away from the display, locate the light

CLASSIFICATION ***CAVEAT***

MASTER MENU

*START DEVICE	GIM
*STOP DEVICE	TSS
WHO	BDT
HELP	RJE
MARK	IN ANAL
USER MESSAGE	*SANITIZER
*PLOT	TELETYPE

*Restricted options

Figure 16. The IISS master menu. Redrawn from *IISS User's Manual*, page 3-5.

pen, position it accurately, note the terminal feedback indicating appropriate positioning, and then press the SEND key to enter the selection. This requires the use of two different command modes, each of which requires the use of different kinesthetic and hand-eye cues. Subsequent interactions require that

CLASSIFICATION ***CAVEAT***

GIM MENU

	ANALYSIS		INPUT	
GIM LANGUAGE	EUNITS	ACTF	EUNITS	ACTF
UTM-GEO	AUNTF	PLATF	AUNTF	PLATF
REPURTW	EOBF	ESYSF	EOBF	ESYSF
	PERSNF	MDLF	PERSNF	MSLF
	RIIF	PPTGT	RIIF	PPTGT
	INSTF	RWYF	INSTF	RWYF
	ARFLDF		ARFLDF	
	ACTIVN		TRANSLATE	

COLUMN #1 FOR USE WITH ALL DATA BASES.
COLUMNS #2, #3, #4, and #5 FOR USE WITH THE TACOB
DATA BASE ONLY

Figure 17. GIM-II Menu on the IISS. Redrawn from *IISS User's Manual*, p. 3-36.

the user locate the light pen clip, place the light pen there, and then prepare to enter data or commands from the keyboard. Thus, the user is required to complete many actions which are not necessary for efficient selection of MASTER MENU and GIM-II MENU options. This may slow users down during high-stress operations.

Menus provide the major method for selecting DS4 processing cycles, and for invoking the data entry and error correction functions. In general, the Run Book menus are very well designed from the user's point of view, with only minor deficiencies. One such deficiency is the method for presenting error messages. When a user selects an illegal option (for example, enters "5" from the master menu illustrated in Figure 18), the system responds with:

```
-> Only entries 0 through 4, 99 and HELP are valid selections <-
```

and then repeats its invitation to:

```
-> Please enter the line number which describes what you want to do <-
```

```
**********DIRECT SUPPORT UNIT STANDARD SUPPLY SYSTEM*******

Hello! I am DS4 and I am ready to help you do your supply
function. Please review the following list of things I can
help you do and select the job you wish me to help you
with:

0       I need help!
1       We want to do Production Processing.
2       We want to do a Data Reduction Function.
3       We need to execute a software utility.
4       We want to do a list of all cycles.
99      It is time to terminate this session.



  -> PLEASE ENTER THE LINE NUMBER WHICH DESCRIBES WHAT
     YOU WANT TO DO <-
```

Figure 18. Master Menu for the DS4 Automated Run Book.

These messages are excellent in that they provide information about legal entries (see 3. Data Entry and Handling). The deficiency appears only if the user commits several errors on the same menu. Each time an error occurs, the error message and correction message are painted on the screen below the pre-

ceding messages. When the bottom line of the screen has been used, scrolling begins--and part or all of the menu might be lost off the top of the screen. This will happen, of course, at a time when the user still needs to be able to read the menu explanation and options. Another deficiency is the space between option numbers and the text description of the option in some menus (for example, the master menu; also, see 6. Glossaries). This space is wide enough to require closer attention than should be necessary to associate an option number with its corresponding description. The width of this space could contribute to errors in entering menu selections (possibly exacerbating the problem described above).

A related deficiency is the arrangement of single-digit option numbers vertically above the tens position of double-digit option numbers (for example, see Figure 19). This arrangement will not be a serious source of errors although it may confuse some individuals at least momentarily. Even so, it detracts from operator "comfort" with the system, because it violates a population stereotype (i.e., most people in Western cultures have learned to expect that numbers will be listed with their units positions lined up vertically).

```
==========DS4 MONTHLY REPORTS-PROCESSES==========

0      I need HELP (FUNCTIONAL GUIDANCE)
1      We need to do a MONTHLY CONSOLIDATION
2 (AP) We need to do a REPORTABLE ITEMS LISTING (AESRS)
3 (AS) We need to do a AUTHORIZEO STOCKAGE LIST
4 (BU) We need to do a BOTTOM UP RECONCILIATION
5 (CS) We need to do a REQUEST FOR CATALOG OATA
6 (DA) We need to do a DMD ANALYSIS (OHA EXTRACT, DMD HIST, DST, ASL UPOATE
7 (DH) We need to do a DEMAND HISTORY UPOATE
8 (FS) We need to do a FINANCIAL STOCKAGE LIST
9 (MK) We need to do a PERIODIC MRO STATISTICS
10(OU) We need to do a OUF UPDATE PROCESS
11(SP) We need to do a SUPPLY PERFORMANCE REPORT
12(TR) We need to do a PERIODIC TRANSACTION REGISTER
13(TS) We need to do a PERIODIC INPUT TRNASACTION STATISTICS
14(CU) We need to do a CATALOG UPDATE PROCESS
15(XP) We need to do a EXCESS PROCESS
99     It is time to TERMINATE THIS SESSION

  -> Please enter the line number which describes what you want to do<-
```

Figure 19. Example of misaligned option numbers in a DS4 Automated Run Book menu.

Whereas command languages and command macros provide powerful and flexible tools to the skilled, experienced user/operator, properly designed menus provide almost as much power to the unskilled, inexperienced user/operator. They break a task down into its components, and then guide the individual through a series of simple, discrete decisions. In this manner, expecially when combined with adequate prompts and HELPS (discussed below), menus greatly relieve the heavy memory burden imposed by command languages and command macros.

And yet, as users/operators begin to acquire experience and confidence with the system, the advantages of menus begin to fade. Even when not yet ready to use command language or other methods, they find menus boring and confining. Many begin to feel that menus slow them down. Possibly, too, menus contribute to a feeling that the computer, rather than the user/operator, controls the interaction.

This is not to say that menus are a panacea. Indeed, anecdotal evidence from systems not included in this analysis suggest that as users/operators gain experience and confidence with their system, some of the advantages of menus start to diminish. Even when not yet sufficiently experienced to use command languages or other control methods effectively, users/operators often begin to find menus boring and confining. Many start to feel that menu sequences slow them down, delaying performance of the functions the computers are supposed to support. Possibly, too, the rigid "lock-step" procedure imposed by menu sequences contributes to a feeling that the computing machinery, rather than the user/operator, controls the interaction.

As an example, consider a situation in which the user/operator needs to enter daily cycle transaction data from the DAS 3 user terminal for processing by one of the DS4 supply cycles. The session begins with the master menu illustrated above, in Figure 18. In the conventional menu sequence, the individual enters a "2" to indicate a data reduction task. The computer responds with a menu of all the available data reduction processes (Figure 20). Since the user/operator wants to enter daily cycle data, the appropriate entry is "2." The system next presents the various daily cycle options (Figure 21). The individual enters a "1" to indicate the need to input new data. The computer responds with its final menu in the sequence, a list of the various methods available for entering new data (Figure 22). The user/operator enters

a "1" to indicate that input will be provided from the user terminal. The system then goes into a prompting mode at this point, to assist the individual to complete the data entry task. This procedure clearly benefits people who are not well acquainted with the computer or its operational sequences. But as the user/operator learns the menu selection sequence through repetition, he or she reaches the point of knowing at the outset that the required string of selections is "2," "2," "1," and "1". It is at this point that frustration may begin to emerge. BETA Test Bed operators, for example, are reported to experience just this kind of frustration with menu sequences in that system.

```
========DATA REDUCTION CYCLE SELECTION========
0   I need HELP
1   We want to do data reduction for PLL Update process.
2   We want to do data reduction for DAILY CYCLE process.
3   We want to do data reduction for CATALOG UPDATE process.
4   We want to do data reduction for PARAMETER UPDATE
    process.
5   We want to do data reduction for UNIT DEMAND HISTORY
    INSERT process.
6   We want to do data reduction for UNIT DEMAND HISTORY
    EXTRACT process.
7   We want to do data reduction for MASS CANCELLATION
    process.
8   We want to do data reduction for REQUEST FOR INVENTORY
    process.
99  It is time to TERMINATE this session.
---> Please enter the line number which describes what you
     want to do <---
```

Figure 20. The menu showing the data reduction processes available on the Automated Run Book.

```
DAILY CYCLE DATA ENTRY/CORRECTION SELECTION

0    I need help!
1    We need to input new data.
2    We want to correct data.
3    We need a combination of 1 and 2 above.
99   It is time to terminate this session.


  -> Please enter the line number which describes what
     you want to do<-
```

Figure 21. The menu used to indicate whether the user wishes to enter new data or correct erroneous data for the daily cycle process.

```
PRODUCTION DATA ENTRY MEDIA SELECTION

0    I need help!
1    We need to enter data from this terminal.
2    We need to input data from card (CDR00).
3    We need to input data from tape (M 900)
4    We need a combination of 1 and 2 above.
5    We need a combination of 1 and 3 above.
6    We need a combination of 2 and 3 above.
7    We need a combination of 1, 2 and 3 above.
99   It is time to terminate this session

  -> Please enter the line number which describes what
     you want to do<-
```

Figure 22. The menu used to indicate which device(s) will be used for data entry during a data reduction process.

1.3 Function keys. Function keys are a prominent design feature in nearly all of the battlefield automated systems encountered during this project. They are, however, configured in different ways in the various systems, and they are used for widely differing purposes.

Both fixed and variable function keys form important components of the overall IISS command mechanism; the fixed function keys are contained in three groups, while the variable function keys are contained in two separate groups (Figure 23). The two separate types of functions are distinguished not only by position, but also by general command function.

The IISS fixed function keys control highly terminal-oriented functions, such as those required for text editing (on the screen of the SU 1652), those indicating that the user is ready to send information from the SU 1652 to the main IISS processor, and those involved in selecting between the SU 1652 dual display screens. These functions depend heavily on the processing capability of the SU 1652. The fixed function keys are always "active;" that is, their associated functions will be enabled any time the key is pressed.

The IISS variable function keys control IISS activities which have more to do with the processor (AN/GYQ-21(V)) than the terminal. The SU 1652 processor must, of course, evaluate the key pressed and generate the correct series of codes to be sent to the processor. In general, however, its role is merely one of formatting and communication. The terminal itself takes no action that is immediately evident to the user. The variable function keys are "variable" only in that they are not always active. The actual function of any particular key is constant, assuming that it is active. The function of the key will not change during IISS operations. It should be noted, however, that--unlike the fixed function keys--the action of the variable function keys can be changed via terminal and system reprogramming. The functions of the variable function keys are not labeled on the keys themselves, but rather on the transparent underlays placed besdie each "strip" of keys. There are lights under each key label cell. When the function is active, the light under the corresponding key label cell is lit.

The extensive use of function keys in IISS has several benefits:

a. It provides a source of constant "prompts" for IISS users, since the key labels are imprinted on the keys or written in the key label cells. This reduces the memory burden on users/operators.

b. It assures that terminology associated with particular functions will be consistent. Since the labels are consistent, programmers maintaining or updating the system cannot mistakenly introduce terminological inconsistency.

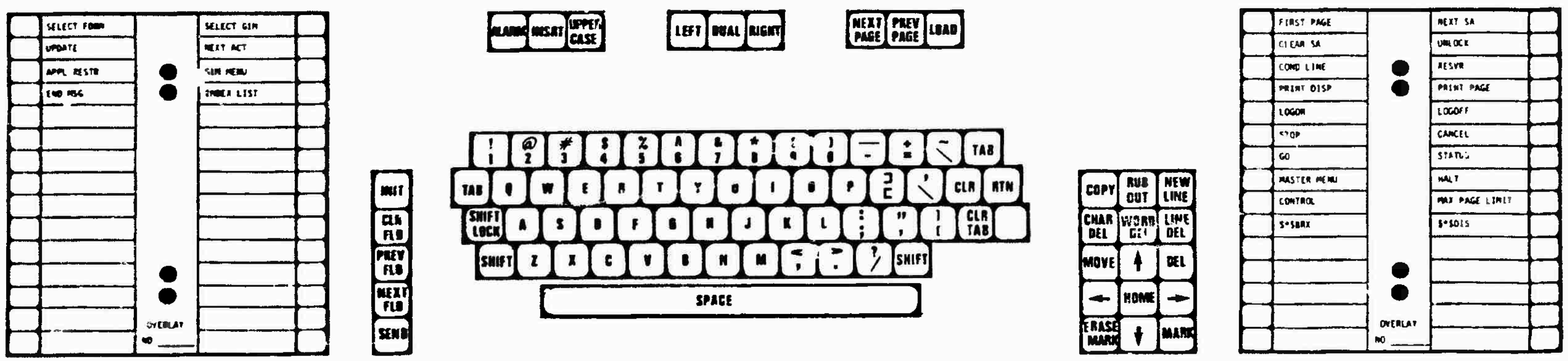

Figure 23. SU 1652 Keyboard and Controls.

c. The way in which the variable function keys are implemented in IISS is particularly useful in reducing user memory burden. Some implementations merely label VFKs with numbers, requiring either that:

   1. The user remember what functions are associated with a specific variable function key number.

   2. A menu be presented on the screen indicating what VFK is to be pressed to perform a particular function. Not only does this method burden system main and peripheral memory resources, but it also requires that the user split attention between keyboard and screen.

The IISS implementation has neither disadvantage. There are, however, ways in which the employment of function keys is sub-optimal in IISS, particularly for novice users/operators.

a. IISS displays do not indicate to the user/operator what function keys (fixed or variable) are typically used in conjunction with the operations to which the displays refer.

b. Where the list of function keys and the explanation of their effects are too lengthy to place on system displays, no function key HELP is available to present to the user the list of the function keys active at the current point in IISS operations.

c. Labels on the VFKs are not very informative--there is certainly room in the VFK labels areas for more text. More informative labels would not degrade the performance of experienced users/operators, but would make the system easier to use by less sophisticated individuals.

Function keys are also employed extensively in the TCT. Two sets of variable (programmable) function keys are located along the right side and bottom of the display screen. The functions of these keys vary with the mode of operation and are identified by labels which appear on the display screen. The TCT also makes extensive use of fixed function keys on both the display panel and the keyboard panel.

In the main, both variable and fixed function keys are used effectively on the TCT. Two features of their use, however, are potentially troublesome. First, the TCT must be initialized each time the system is moved, and each time task organization changes the configuration of communications equipment and computer terminals. The initialization procedure involves two "pages" of display formats, into which the user/operator enters initialization data. There appears to be no conceptual distinction between pages 1 and 2; they are

always completed in the same sequence, and both pages must be completed to initialize the TCT. Available documentation describes no processing options after page 1 is completed; the user/operator must proceed to page 2. However, to obtain page 2 displays, the user/operator must press the DATA INIT and CHNG FCTN keys. The user/operator must remember, first that function keys are required to obtain page 2 displays, and second the proper sequence of key presses. While not great, the memory and administrative burden imposed upor the user/operator by this requirement is unnecessary. Second, at various points in TCT operations, the system presents a "mode selection alert" to the user/operator. This alert indicates that the user/operator must select one of the system's available modes of operation. The mode selection procedure is not uniform for all modes, however.

a. To select the TEXT EDIT or DATA ENTRY modes, the user/operator must press and hold down the interlock key (INTLK) while simultaneously pressing the appropriate mode selection key.

b. To select the CYCLE MSG or REPL modes, the user/operator merely presses the appropriate mode selection key, the INTLK key need not be used.

The system does not provide any prompts as to when the interlock key is required or not required. Therefore, the user/operator must remember which modes require the interlock key, and which do not. This requirement imposes an unnecessary memory burden.

The majority of TACFIRE function keys are contained on the ACC SPA (Figure 24); function keys on the VFMED and DMD are more limited in number, but those available perform functions similar to their counterparts on the ACC.

The function keys generally are straightforward in their labels and operations. One exception to this general rule is the DELETE key. Pressing this key on the SPA clears the RD and displays the next message. The message is automatically cleared and removed from the receive queue when the DELETE switch is pressed. If a segment of a message is being displayed, only that segment of the message is deleted. However, if the segment that is deleted happens to be the first segment of the message, the entire message is deleted, i.e., removed from the RD and also removed from the message queue. There is no protection feature for priority messages. The operator could inadvertently delete an important message by accidentally pressing the delete switch or by not

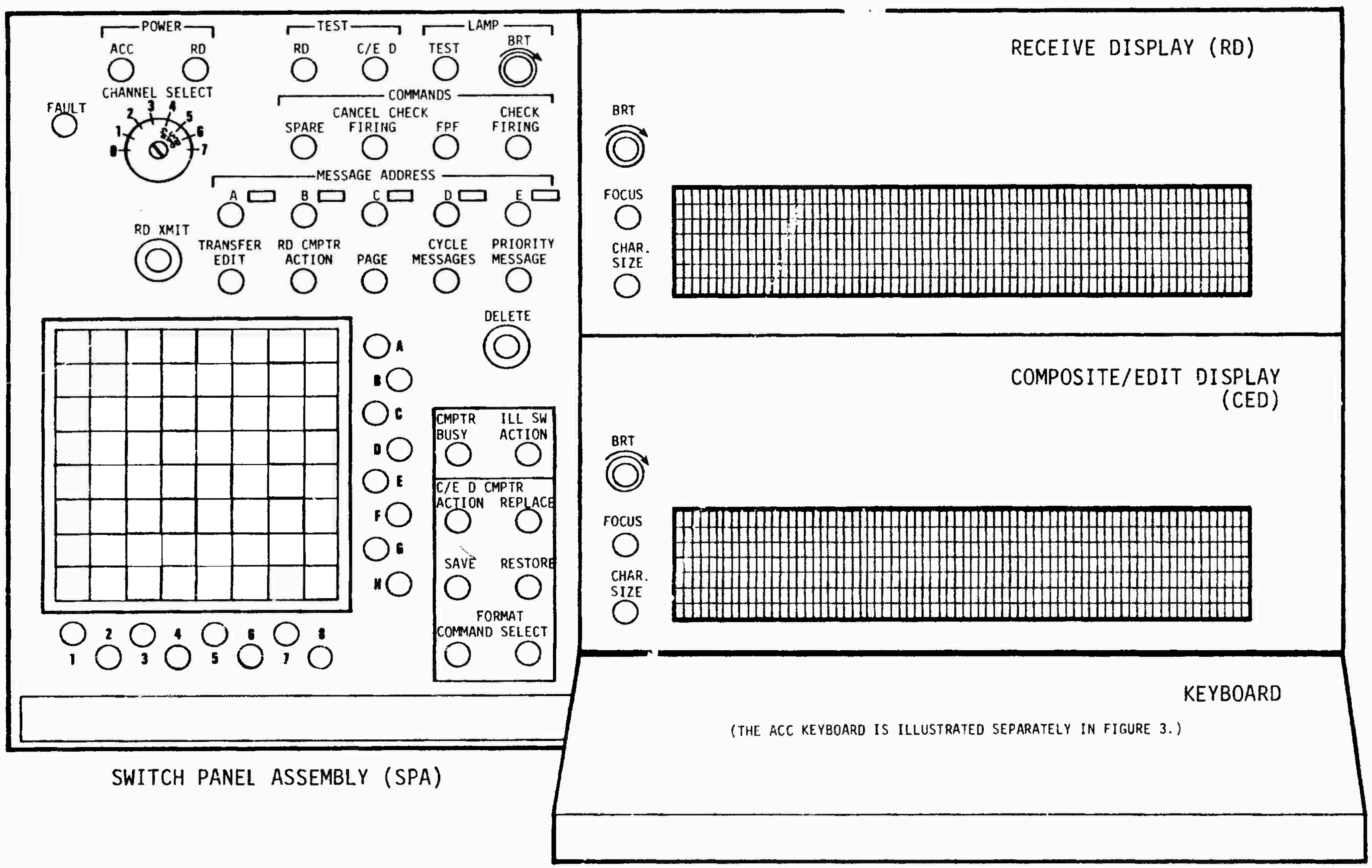

Figure 24. Configuration of the Artillery Control Console.

recognizing that deleting the first message segment will delete the entire message. Unintentional deletion of the first segment will delete the entire segmented message. Thus, important messages could be lost inadvertently.

Although the DAS 3 user terminal is equipped with a variety of function keys, only the cursor control keys are used in the DS4 Automated Run Book. In this connection, two deficiencies are apparent in the data reduction function. Both are potentially troublesome. First, if user/operator enters an erroneous character and then detects the error before leaving the data field, it is possible to correct the error. The first step is to move the cursor back to the error character, either by pressing the "@" key or the "<—" cursor control key (but not by pressing the "BACKSPACE" key, it acts like the "TAB" key). The next step is to press the key for the proper character, thereby overprinting the error character on the screen. However, what the user/operator sees on the screen may or may not reflect what will go into the computer when the data entry is completed and the "RETURN" key is pressed to enter the data. For example, suppose the user/operator intends to type "YEH," inadvertently types "YEF," moves the cursor back to the "F," and types "H." On the screen, the individual will now see "YEH," the proper character string. However, the character string that will be entered into the computer depends on how the cursor was moved backward. That is, if the user/operator pressed the:

a. "@" key, the "H" will replace the "F" on the screen and in the input character string, so that the computer will receive "YEH."

b. "<—" key, the "H" will replace the "F" on the screen but not in the input character string, so that the computer will receive "YEFH."

Clearly, using the "<—" when attempting immediate correction of typographical errors will result in processing errors as well; time will be wasted, users/operators will be frustrated, and errors may be introduced into the DS4 data base. Unfortunately, this may well become a frequent problem in the field because the "<—" naturally lends itself to moving the cursor backward. This is especially true for personnel who have had experience on other systems.

Second, in the error correction mode, correcting an error card begins with the system painting an 80-column image of the card near the

top of the screen. The user/operator can compare this image with the error card itself, on which have been indicated the data fields containing errors and the corrections to be made. If the Document Identifier Code (DIC) is wrong, it is corrected in the horizontally formatted card image. Then, to edit the remainder of the card, the user/operator presses the "RETURN" key. The system breaks the horizontal card image into separate data items, with one item per line. Each line shows the card column(s) in which the data item appears, a field identifier that also serves as a prompt, and the data currently in that field. The column numbers and field identifiers are protected; after the entire display is painted, the cursor returns automatically to the first character position of the data field on the second line (the first item--the DIC--was corrected, if necessary, on the horizontally-formatted card image). The user/operator may either change the existing entry by typing in the correct data, or accept the existing entry by skipping the field. To advance to the next data field, the individual may press any of four keys: "RETURN," "TAB," "BACKSPACE," or " ". The editing operation is not completed until the user/operator either has entered correct data in the data field on the last line, or else has skipped past that field. Thus, if only the second field must be corrected in a transaction of, say, twelve fields, then the user/operator must press "RETURN" (or "BACKSPACE," or "TAB," or " ") ten times after correcting the error before he or she can proceed to the next transaction. While the necessity to do so probably will not increase error rates, it does consume time and contribute to boredom, frustration, and antipathy toward the sytem.

1.4 Hybrid methods. Hybrid methods are combinations of methods used to control the sequence of operations in a computer. Thus, function keys might be used to indicate menu selections, or menus might be used to list command verbs. The most unique hybrid method observed in both the initial survey and more detailed analyses is the format selection matrix on the TACFIRE ACC SPA. This matrix, illustrated on the left side of Figure 24, contains 64 cells in an 8 x 8 arrangement. A paper overlay, listing format designator codes, is fitted over the matrix. In use, when a message format is required for entering data, the format must be called up from storage. To select a message format, the user/operator first locates the proper code on the matrix, then pushes one button below the column in which the code is located, and finally, pushes

another button to the right of the row in which the code is located. The intersection containing the desired message format code first must be located. Then, the user/operator must track both horizontally and vertically to locate the buttons required to identify the proper intersection. The procedure requires careful eye-hand coordination to avoid errors.

Another problem with the format selection matrix arises from the fact that matrices at division and battalion have 47 format name codes in common. Of these, 19 are placed in the same location on the matrices at both division and battalion (the codes enclosed in boxes in Figure 25). The remaining 28 common codes are at different locations on the two matrices (the codes in circles in Figure 25). Users/operators who transfer from battalion to division or vice-versa will confuse locations on their "old" matrix with those on their "new" matrix. This confusion, which will be greatest for the user/operators with the greatest experience, will greatly increase the probability of errors.

The wide variety of command methods available in IISS virtually assures that some hybrid methods will be employed. The most significant and pervasive combinations employed in IISS are: (a) combination of form filling, menus, and fixed function keys; (b) of light pen and function keys; and (c) the variable function keys.

Combination of form filling, menu, and fixed function key methods. Using the MMI forms to control IISS operations requires that all three of these methods be employed:

a. Form filling is the core command method, since codes must be entered into the MMI forms to define subsequent processing operations.

b. Menu selection is used to provide the list of "switch" commands which may be used to complete the forms. This aspect of the command is advantageous since it obviates remembering the "switch" command language.

c. Fixed function keys are used to position the screen cursor in the appropriate field for switch entry.

Combination of light pen menu selection and fixed function key methods. When the MASTER MENU and the GIM MENU are used in IISS, the user first uses the SU 1652 light pen to select the desired option. The user must then press the SEND key to transmit the selection to the main IISS processor.

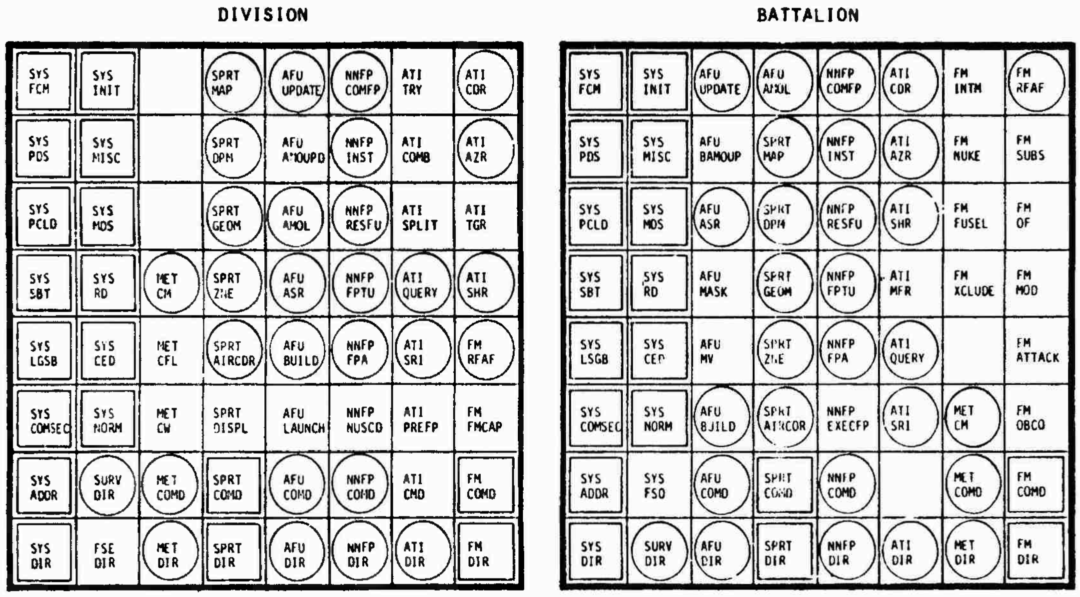

Figure 25. TACFIRE SPA Message Format Selection Matrices for Division and Battalion Computers.

Use of variable function keys throughout IISS operations. The highly flexible variable function key configuration of the SU 1652 allows it to be used in IISS when a variety of other command methods are being employed. In many such circumstances, the variable function keys form a constantly available set of "global system options."

The TCT and the DS4 Automated Run Book do not incorporate hybrid methods such as those described above, although, as noted earlier, the TCT uses menus to help the user/operator to choose the appropriate data item for many message fields.

1.5 Prompts/HELPS. Battlefield automated systems utilize a wide variety of prompts, although HELPS are more plentiful in some systems than in others. Both of these features are exemplified in the paragraphs that follow.

The TCT provides extensive prompts. For example, recall the SITREP message in Figure 15, under "1.2 Menus." As noted there, the system provides menus for those data fields for which the list of legal values is short. When the list of legal values is longer, the system provides an instructive prompt. Figure 26 provides an example. Notice in the figure that, instead of a menu

of possible values for the first data field, the Prompt Display Area of the screen contains an instructive statement of what the user/operator should do, and information about the range of legal values for the field.

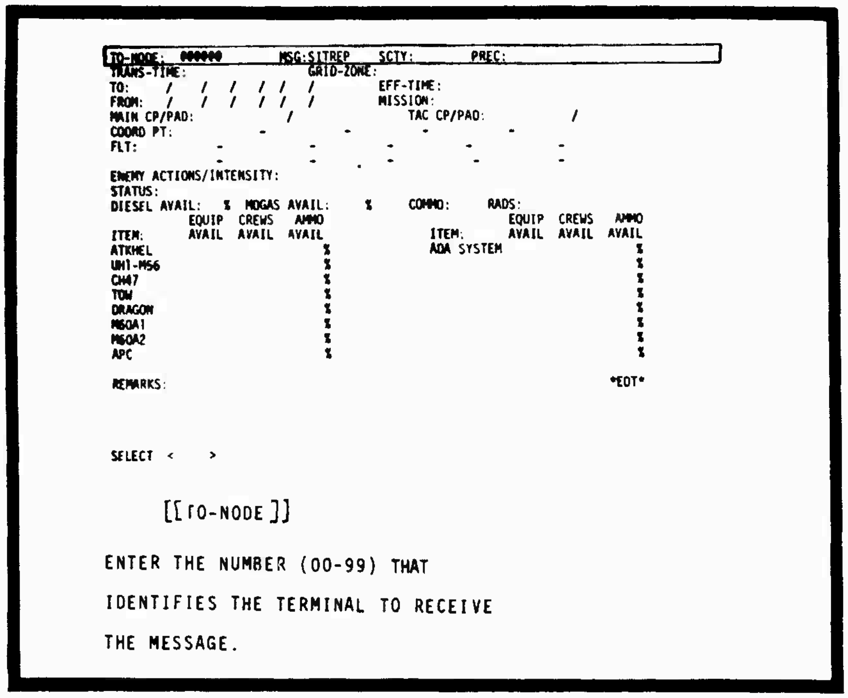

Figure 26. The SITREP message format with prompt for first data field at bottom of screen.

Although prompts in the TCT generally are well-designed, problems were observed in a few cases. For example, after the user/operator has initialized the TCT, the message "INITIALIZATION IS COMPLETE" appears in the operator alert area of the display screen. At this point, the user/operator must select one of the system's four modes of operation in order to continue processing. However, the system provides no indication that the user/operator must take some action. The user/operator must remember that an action is necessary after the "INITIALIZATION IS COMPLETE" message appears. In this situation, an inexperienced user/operator, or one under stress, may simply wait for the system to provide instruction for the next transaction (especially in the TCT; because it has generally good prompts, user/operator personnel are "trained" to expect prompts). Even if he or she remembers that a mode must be selected, the user/operator must still recall the four modes of operation and their associated designators. Also, during TCT initialization, the user/operator specifies the

characteristics of communications channels, selecting from menus. For example, to select the device, one of the following is entered:

1. KY-57
2. MODEM
3. CAU
4. LOCAL RADIO
5. REMOTE RADIO
6. 2-WIRE
7. 4-WIRE
8. CURRENT LOOP

Some of the terminology used in the menu (e.g., KY-57, MODEM, CURRENT LOOP) may be excessively technical for users/operators, forcing them to remember unfamiliar designations.

Consistency in the construction of prompts is also a minor problem in the TCT. For example, in the SITREP and GRAP message formats, the prompt for identifying the receiving terminal node is: "ENTER THE NUMBER (00-99) THAT IDENTIFIES THE TERMINAL TO RECEIVE THIS MESSAGE." The SPOT and FREE message formats also require the user/operator to identify the receiving terminal node. However, in these two messages, the prompt is: "ENTER THE NUMBER IDENTIFYING TERMINAL TO RECEIVE THIS MESSAGE." The difference in wording between the two functionally identical prompts provides an unnecessary opportunity for confusion. The failure to indicate the range of legal values in the second prompt adds another opportunity for confusion in the SPOT and FREE messages.

Prompts are also plentiful in TACFIRE. That is, the 8 x 8 format selection matrix and the individual format directory menus provide prompts regarding message format identifiers (e.g., FM;RFAF). Also, each message format contains data element names to prompt the user/operator to enter data in the element fields. Many of these prompts are highly meaningful (e.g., "COORD" for coordinates and "FUZE" for fuses) and aid the user/operator to decide what data are required in the element field. However, TACFIRE is inconsistant in regard to prompts, in two ways. First, many prompts cannot easily be associated with a data type (e.g., "D" does not associate with subscriber index number).

Second, the same prompt is often associated with more than one data type (e.g., "D" refers to subscriber index number in the SYS; ADDR message, and to command post location and closing time in the AFU;SR message). These issues are discussed further under "6. Glossaries."

Prompts are used extensively in the Automated Run Book. Menu items, of course, provide explicit prompts for selecting functions. Questions provide prompts to elicit parameters required to generate ECL card images. Prompts are also provided in both data entry and error correction. In general, prompts appear to have been well-designed, providing clear and specific information about what is needed from the user.

A certain amount of prompting is always presented in the IISS, in the form of the FFK legends and the illuminated labels associated with the VFKs. Beyond these, the availability of prompts in the system depends on the particular operating mode. For example, the MMI mode uses input forms and menus. This mode includes a variety of prompt types, including data field labels on interactive forms, "switch lists" providing information about legal software switches for a given form, and the menu contents themselves providing lists of legal values. In other modes, prompts tend to be terse and uninformative, as in the COPY option of the TELETYPE mode. The sole prompt for this option is "COP>." The lack of information in prompts is particularly unfortunate in view of the system's HELPS, discussed below.

HELPS are software routines which allow the user/operator to break out of the normal procedure for a transaction, obtain assistance regarding definitions of terms or values of legal entries, and then return to the point at which the normal procedure was interrupted. These HELPS, of course, are of greatest assistance to the inexperienced user/operator, because they provide immediate aid online, at the point of difficulty, without the need to consult off-line sources. But HELPS are necessary for experienced users/operators as well, when they work with an unfamiliar portion of the system, or after a period of time away from the system. This is particularly true when the system is complex.

IISS is an extremely complex system. As such, there are a wide variety of functions and input codes which have to be used by IISS intelligence analysts. And yet, IISS provides only a single HELP display (Figure 27), which provides a brief description of the major MASTER MENU and TELETYPE capabilities of the

system. No other HELP information is available on-line (except for function key labels). Explanatory information is available in hard copy but is spread across several documents. Even the single HELP display illustrated in Figure 27 provides rather terse information. Furthermore, in some cases, the contents of the HELP display are inconsistent with available IISS processing options:

a. The HELP display includes a reference to a HALT option. This capability is not listed on the MASTER MENU, nor is it discussed as one of the TELETYPE options.

b. The HELP display contains no reference to the SANITIZER option, which is available from both the MASTER MENU (the SANITIZER option) and the TELETYPE (the MMU > CBL option).

c. The HELP display contains no reference to the PLOT option, which is also available in both MASTER MENU and TELETYPE modes.

d. The HELP display includes a reference to a NOTE option, which is not presented in the MASTER MENU nor in the TELETYPE documentation in the IISS Users Manual.

The user/operator will have to resolve the inconsistencies between the HELP display and the manifest capabilities of IISS. This will be confusing, and may lead to hesitancy on the part of users/operators to employ required capabilities. Without a well-conceived HELP capability, the complexity of the system imposes

```
CLASSIFICATION

   HELP -- HELP OPTION (SHORT/LONG MISSING LONG DEFAULTED)
   OPTION         DESCRIPTION
   BDT            BULK DATA TRANSFER -
   COPY           COPY INPUT TO OUTPUT
   DSPLY          DISPLAY VERB ENTRY POINT FROM MENU
   GIM            GENERALIZED INFORMATION MANAGEMENT
                    SYSTEM (LOCAL)
   HALT           LOGOFF AND HALT TERMINAL
   HEADER         ALTER SECURITY HEADER
   HELP           USER OPTION LIST
   LOGOFF         LOG OFF
   MSG            SEND MESSAGE TO USER LOCAL OR REMOTE
   NOTE           COMMENTS, NO OPERATION
   PRINT          PRINT VERB ENTRY POINT FROM MENU
   RJE            REMOTE JOB ENTRY
   SCRTCH         SCRATCH VERB ENTRY POINT FROM MENU
   START          START DEVICE
   STOP           STOP DEVICE
   TSS            TIME SHARING ON THE H-6000
   WHO            USER STATUS REPORT
```

Figure 27. The List of Function Descriptions Resulting from Selection of the HELP Option from the Master Menu. Redrawn from *IISS User's Manual*, p. 3-8.

significant memory burdens on its operators. They must either commit all of the information to memory or refer to external documents if their recall fails.

No HELPS were observed in the TACFIRE system. The lack of such HELPS is a serious deficiency. The system has over 200 messages incorporating over 900 different data fields (see also "6. Glossaries"). With no on-line assistance to define data field codes (many of which cannot be associated meaningfully with the type of data to be entered), the user/operator must refer to off-line sources (running to 10 volumes) for assistance at virtually any point of difficulty.

At the time that the DS4 Automated Run Book was analyzed, only a few HELPS had been implemented. These few were quite good, containing information relevant to the task, and written in clear and explicit language. Other HELPS will be added as development continues: developers should be encouraged to show as much concern for the system's prospective functional users/operators as they have shown thus far.

The TCT provides HELPS in the form of operator and system alerts displayed on the plasma screen. Operator alerts provide direct instructions to the user/operator regarding some sources of action. System alerts are more cautionary, or identify courses of action dependent upon other system indicators.

2. Display Format

Display formats are a particularly important aspect of the user-computer software interface. The arrangement and organization of display formats can present information in logical, natural orders, with adequate separation among fields to facilitate locating particular items, and thus greatly enhance user/operator performance. Conversely, they can present information as a disordered jumble, with data items densely packed and inadequately labeled, and thus actually degrade user/operator performance. In general, battlefield automated system developers have recognized the importance of good display design, although a number of problems were observed, as noted below.

2.1 Fixed alphanumeric displays. On the IISS, the dual 80 column by 24 line screens of the SU 1652 provide a great deal of flexibility in creating alphanumeric displays. The "screen area" organization of the displays does, however, somewhat constrain the available display space. IISS fixed format

alphanumeric displays are generally well organized for readability. There are, however, two exceptions to this general rule:

a. Individual TACOB fields are often not organized for maximum readability. In particular, geographic coordinates, UTM coordinates, dates, and times should be broken into subfields for display. Geographic coordinates provide one example. Geographic coordinates are displayed by IISS primarily to indicate the position of units in the TACOB order-of-battle files. These coordinates are provided in one or both of two forms:

1. Latitude/longitude (GEO), which has the format:

   ddmmssAdddmmssA
   Lat Lon

   where:

   d = degrees (maximum of two characters for latitude; maximum of three characters for longitude)
   m = minutes
   s = seconds

   A_{Lat} = N (North) or S (South)
   A_{Lon} = E (East) or W (West)

   An example of a GEO display is 354327NØ97280ØlE

2. Universal Transverse Mercator (UTM), which has the format:

   nnAAAnnnnnnnn

   where:

   n = numeral

   A = alphabetic character

The IISS document does not further define the UTM format.

The IISS user/operator is sometimes required to copy geographic coordinates information from one place to another (as, for instance, in UTM/GEO or GEO/UTM conversion). The user/operator must break the geographic coordinate into its separate subfields (e.g., dd-mm-ss) mentally. The probability of misreading the closely packed characters is thus relatively high.

b. Where display space is not at a premium, both the labels of TACOB record elements and the contents of those elements should be expanded to increase meaningfulness. A field currently labeled RRDAT, for example, might be translated for the

user/operator to read READ. RATE DATE or READINESS RATING DATE. This approach will be particularly useful where:

1. Users/operators have not had time to gain significant experience in the use of IISS.

2. Functions are used rarely (e.g., IN ANAL).

TACFIRE displays are severely limited in regard to space. Each display on the ACC and VFMED is fixed at 7 lines and 72 columns. As a result, displays tend to be densely packed with information, making difficult any attempt to scan a message to find a selected data item or to review a completed message for accuracy and completeness. In addition, the VFMED is a "dumb" terminal; it contains no storage, processing capability, or message buffer. Thus, after transmitting a request to the computer for a message, or after transmitting a completed message, the display screen must be cleared before the next message arrives. If the screen is not cleared before the new message arrives, the new message simply overprints whatever is on the screen at that moment. The VFMED user/operator must take overt action to clear the display screen before an incoming message arrives. In a busy situation, such as an exercise or tactical operation, the user/operator may forget to perform this procedure. An arriving message, overprinting the screen's existing contents, may be uninterpretable. The transaction will be delayed while the user/operator requests transmission of a new "copy" of the required format. Alternatively, the user/operator may elect to attempt reconstruction of the "garbled" message by typing in the overprinted portions. This procedure would require the user/operator to type in data element names--in precisely the correct character positions--as well as the data that he/she normally enters in element fields. This is a time-consuming and highly error-prone procedure.

An even more serious problem concerns the arrangement of data fields in TACFIRE messages. Data fields common to two or more message formats often appear in different places from one field to the next. For example, the codes "FRLT," "NFL," "FCL," and "DSA" appear in two message formats used to input battlefield geometry data (SPRT:GEOM and SPRT:BUILD). The codes appear on different lines in the two formats, in different orders within the lines, and in different column groups. Users/operators must exercise care in switching from one message format to the other not to confuse the sequence of codes. This requirement imposes an unnecessary burden on the user/operator in terms of memory load and attention to detail.

Output reports also present problems. Some output reports have headings or identifiers (e.g., SYS;1201), while others don't. On the latter, the information is merely printed out, and the user/operator must recognize the report by its content. Also, some reports have the same identifier, but different contents. For example, a SYS;1201 report can contain a list of all message types authorized, a list of subscribers, a list of legal message types for input, a list of legal message types for auto relay, and a list of message addresses. The various segments just described can also be printed separately; each such segment will be identified as SYS;1201. There is great potential for confusion between various segmented and complete reports as users/operators search for specific items of information.

All displays observed in the DS4 Automated Run Book fit in the category of fixed alphanumeric displays. The only variable elements in the displays are the values entered into data fields; the fields themselves are of fixed length. Fixed alphanumeric displays are appropriate for the applications implemented in the Automated Run Book. They are generally well-designed to facilitate user interaction with the computer. No deficiencies were observed in this category (however, see 2.4 Highlighting).

The TCT uses a two-page fixed alphanumeric display for system initialization, and four preformatted fixed alphanumeric displays during system operations. The TCT message formats are well designed in that they are not cumbersome either in size or density. Data fields containing multiple pieces of information of fixed length (e.g., TO, FROM) are appropriately sectioned off to guide the user/operator in data entry. For other alphanumeric fields of fixed length (e.g., TRANS-TIME), the prompts are such that size and data entry type (alpha versus numeric) are clearly indicated to the user/operator.

2.2 Variable-length alphanumeric displays. Variable-length alphanumeric displays are not a common feature in battlefield automated systems. The DS4 Automated Run Book and the TCT do not incorporate any displays of this type, and no plans are known to implement them. TACFIRE documentation refers to segmented messages, but these appear to be sequences of fixed alphanumeric messages strung together. In IISS, the only known variable-length alphanumeric display is the "INDEX LIST," which lists data records from the data base that satisfy criteria entered previously by the user/operator. While the length of the INDEX LIST varies with the number of data records satisfying the criteria,

the display in other respects has the characteristics of a fixed alphanumeric display. Thus, the analysis of systems yields no important results in this category.

2.3 Graphics displays. Few important results emerged from the analysis in regard to graphics displays. Though most systems appear to have at least some graphics capability, in some it is not used (for example, the DS4 Automated Run Book) or used infrequently. TACFIRE provides graphic display capability only with the DIVARTY computer. The major problem noted in connection with this device is that it presents information essentially in "free space." That is, the device has no capability to use map overlays or underlays, and it does not display identifying terrain features. Thus, graphic symbols appear on the display without contextual information, necessitating frequent references to a separate map. Perhaps as a consequence, the graphics plotter apparently is not used often.

A graphic display capability is incorporated into TCT. However, graphics were not considered part of the Phase 1 implementation of TCT and therefore, no transaction feature analysis was possible.

No true graphic or pseudo graphics (i.e., graphics constructed from characters) are available at the SU 1652 terminal. Geographically-oriented plots are available using the PLOT option, but this option is not currently implemented for IISS analyst users. These plots must be performed with the assistance of highly skilled system operators. Plots are made on a Calcomp flatbed plotter. The review team did not have an opportunity to assess plotter formats or symbology.

2.4 Highlighting. Developers of battlefield automated systems appear not to appreciate the value of highlighting. Highlighting is the use of color, brightness changes, underlining, blinking, or other distinctive variations from the normal appearance of the display screen. It is used to draw a user's/operator's attention to a particular area of the display containing especially important information such as alerts or error messages, or to help the individual locate important words or phrases. Used in these ways--and used sparingly, highlighting can be an effective aid to enhanced user/operator performance.

Only one highlighting feature was observed in the TCT. As shown in Figure 15 and again in Figure 26, a box is put around the line on which data are being entered into a message format. This box would be more effective if it surrounded only the data field currently being entered; nonetheless, it at least helps the user/operator locate the line containing that field.

The only instance of highlighting in TACFIRE occurs on the DMD, where the element name flashes to identify the data element currently being completed. The ACC and VFMED apparently have no highlighting capability to draw the user's/operator's attention to particularly important portions of the display.

Even when developers have greater highlighting capability, either they have not used it at all, or they have not used it as effectively as they might. For example, in IISS, the SU 1652 has a number of features which could be employed to highlight important information, including brightness control, reverse display, and blinking. IISS does not, however, use any of these forms of highlighting.

The DAS 3 user terminal has extensive highlighting capability: blinking, inverse video, two levels of brightness, boxing (using graphics features), and upper and lower case. The DS4 Automated Run Book's developers have utilized some of these capabilities effectively, although not consistently. For example, consider Figure 28, which contains two examples of inconsistent highlighting.

```
Here is a recap of what I think
you have asked for to this point:

*
1      We want to do Production Processing.
2      We want to do a WEEKLY report-process.
1      We need to do a WEEKLY CONSOLIDATION
*
Does the recap indicate we are about to do the proper
report-process?
Please enter YES or NO
Y
good, we can now proceed
```

Figure 28. A sample of Automated Run Book output illustrating two examples of highlighting used inconsistently.

First, notice that sentences in the display begin with a capital letter, except for the last sentence, in which "good" begins with a lower case letter. Second, upper case letters are used to highlight important words in the display, such as "WEEKLY CONSOLIDATION," "YES," and "NO." But "Production Processing," surely of equal importance, is capitalized in the first letters only.

Similarly, in the data reduction function, prompts are displayed with lower brightness than data entries. However, the same highlighting procedure does not appear to be used in the production processing function when questions are used to prompt the user for ECL parameters.

Such inconsistencies (also see 6. Glossaries) are not likely to be serious sources of error, nor are they likely to cause delays in data processing operations. However, even minor inconsistencies can introduce a jarring note into the user/computer relationship, adversely affecting the user's "image" of the system. That is, they can detract from the user's view of the computer as a well-designed, properly-functioning, reliable tool, thereby affecting the user's acceptance of the system.

3. Data Entry Assistance

3.1 Information on Legal Entries. The battlefield automated systems that were studied varied widely in the extent of legal entries information they provide on-line at the terminal. All of the systems provide some information on the format of information to be entered. IISS, for example, indicates the maximum length of input fields by displaying underlines (Figure 29) in its fill-in-the-blanks data entry forms. TACFIRE uses dots for the same purpose (Figure 29). TACFIRE also uses virgules (slashes) and commas to indicate subfields within the data entry fields (IISS also uses the virgule technique, although less consistently). The DS4 Automated Run Book uses underlines to define field lengths in its "production process" input and edit routines; copies of screen formats were not available for inclusion in this report.

TCT provides some input format information when the data to be entered is not categorical (e.g., the string to be entered is an integer between 0 and 180). Legal values information about formats is less necessary in this system than in others because of its use of input menus. DLDED is not yet sufficiently developed to permit comment upon its handling of legal entries formats.

```
CLASSIFICATION                                    ***CAVEAT***

                              DISSEMINATION HEAOER

EXPLICIT AOORESSEE(S):_____________________________________________
(SEPARATE WITH COMMAS)_____________________________________________

ACTIVITY:
   TYPE     :_____                                MESSAGE TYPE:_______
   LOCATION:_________                             PRIORITY    :_______
   OTG      :___________
   UNIT     :___________________________          RETENTION   :_______

                       AVAILABLE JINTACCS MESSAGE FORMATS

      RII           JRSRR           TACREP          TGTINFOREP
      RRII          INTREP          SENREP          MIJIFEEDER
      OISUM         INTSUM          TARBUL          JTACARSREQ
      JRSRR         MISREP          TACELINT        HOTPHOTOREP
      JNP128
```

IN ANAL dissemination header form, showing underlines used to define maximum field length. Redrawn from *IISS User's Manual*, p. 3-20.

```
......;P:.;SB:././././.,/...;C:...;SG:..,..;DT:..,../../..;ID:....;A:.;
MET;CFL;Q:.;POSI:......;DTI:../..,./.;HGT:...;
LINA:../.../...,../.../...,../.../...,../.../...,../.../...,../.../...;
LINB:../.../...,../.../...,../.../...,../.../...,  /.../...,../.../...;
LINC:../.../...,../.../...,../.../...,../.../...;
```

Sample TACFIRE formatted message, showing dots used to define maximum field length.

Figure 29. IISS and TACFIRE formats indicating maximum field lengths.

There is much less consistency in the extent to which these systems provide the user/operator with information about the permissible content of data entries. All used some variant of the "fill-in-the-blanks" form of information entry, but the human factors design quality of the implementations is quite variable. The best of the lot appears to be TCT. Its message forms are superficially similar to those of TACFIRE (see Figures 29 and 30), but the technique for getting information into the message "blanks" is completely different. In TACFIRE, the user/operator must enter the data without any form

```
TO-NODE: @@@@@@      MSG:SITREP     SCTY:...........      PREC:.........
TRANS-TIME:........... GRID-ZONE:...
TO:   .../.../.../../../.../.....        EFF-TIME:............
FROM: .../.../.../../../.../.....        MISSION:.............................
MAIN CP/PAD:........./.........             TAC CP/PAC:........./...........
COORD PT:........-.........-.........-.........-.........
FLT:........-.........-.........-.........-.........-.........
    ........-.........-.........-.........-.........-.........
ENEMY ACTIONS/INTENSITY:...............
STATUS:
DIESEL AVAIL:...%    MOGAS AVAIL:...%      COMMO:      RADS:....
               EQUIP   CREWS   AMMO                    EQUIP   CREWS  AMMO
ITEM:          AVAIL   AVAIL   AVAIL        ITEM:      AVAIL   AVAIL  AVAIL
ATKHEL          ...     ...     ...%        ADA SYSTEM  ...     ...    ...%
UH1-M56         ...     ...     ...%        ..........  ...     ...    ...%
CH47            ...     ...     ...%        ..........  ...     ...    ...%
TOW             ...     ...     ...%        ..........  ...     ...    ...%
DRAGON          ...     ....    ...%        ..........  ...     ...    ...%
M60A1           ...     ...     ...%        ..........  ...     ...    ...%
M60A2           ...     ...     ...%        ..........  ...     ...    ...%
APC             ...     ...     ...%        ..........  ...     ...    ...%

REMARKS:..............................................................
.............................................................*EOT*
```

Figure 30. Sample TCT Message Format. Reproduced from *Tactical Computer Terminal User Manual for Phase 1 of European Implementation Plan (Preliminary Draft)*. Glendale, California: Librascope Division of Singer, 1 August 1980. NOTE: dots appear only in manuals; they are not displayed on the terminal screen.

of prompting. If the individual forgets the legal values for a certain data entry item, a hard copy reference manual must be consulted. This design feature imposes a significant memory burden. TCT, on the other hand, presents the user/operator with an input menu (recall the bottom of Figure 15), which provides the legal values for all of the possible entries in the data field into which data are currently being entered. This data entry feature has the collateral benefit of reducing the number of keystrokes required for data entry, since the user/operator is selecting a numbered item from a menu rather than entering a lengthy string of characters.

Data entry in IISS can be accomplished in two different ways. Entering data into the order of battle data bases via the MMI (man-machine interface) mode is accomplished by filling in blanks in a data entry form. No information on the contents of legal entries is provided. In GIMS language mode, the user/operator does not even have data field labels to cue data entry; both "field" or "variable" labels and data entry codes and/or formats must be recalled from memory.

Data entry in the Automated Run Book of the DS4 is also accomplished by filling in the blanks in a data entry "form" printed at the user terminal. Essentially no information on the legal contents of these fields is provided.

All of the systems examined provide legal entries information in hard copy reference manuals; none provides pointers from specific data entry displays to sections or individual pages of code books or other reference documents.

All in all, the TCT approach of providing legal values in menus appears to be the most appropriate for U.S. Army battlefield automated systems. All legal values are provided for the user/operator, and, for those data fields where a fairly small set of categories are available, there is no need to provide information on legal values formats. This technique should be particularly valuable for inexperienced personnel, who may not be as comfortable with the entire spectrum of permissible input values as their more experienced counterparts.

There are two potential problems with the use of menus for providing legal values information in the form of input menus. The first of these concerns the handling of data fields where the range of possible responses is finite but large. Since the display space for menus is limited, the designer may be forced to provide multi-page menus to provide all legal entries. This may force the user/operator to page through the menu lists until the desired data entry is located. This process is time-consuming, and may frustrate experienced operators/users. The second problem involves the entry of information by very experienced users/operators. Even reasonably well designed menu data entry systems may become unsatisfactory to personnel who are able to anticipate their desired data entries several steps ahead (see 1.2 Menus). This problem can be particularly acute when many of the entries are optional menu systems cannot anticipate which entries must be filled in, and which may be left blank. A third potential problem with menu-oriented data entry systems involves data entry items with permissible responses which are not categorizable, such as dates, ranges, etc. The appropriate strategy here may be to be replacing the menu with a relatively detailed set of information about the format of the response required. This is the approach taken in TCT, and in the production processing portion of the DS4 Automated Run Book.

3.2 Unburdening of Input. All of the battlefield automated systems in the sample use at least one method to reduce the number of keystrokes: coding and/or abbreviation of data entry values. All also have some method for propogating constant information (such as the current date) so that it need not be repeatedly re-entered by users/operators. Other methods for unburdening of input are tied to the interaction idiosyncracies of the particular systems. IISS, for example, features a number of provisions designed to reduce the amount of information which its users must enter to build and maintain order of battle files. Included are:

a. Automatic generation of geographic coordinates.

b. Automatic generation of dates.

c. Automatic update of position tracks.

The DS4 Automated Run Book prints out the existing information for transactions to be edited, relieving users/operators of the necessity to re-enter correct information.

There was little evidence of some of the more sophisticated methods for reducing the input burden on users/operators, such as probabilistic generation of candidate data entries and user-directed specification of data entry contractions. There is considerable evidence, however, that some relatively straightforward techniques for reducing the user/operator data input burden have not been employed in battlefield automated systems. TACFIRE, for example, has no provisions for automatic cursor placement during error correction or for skipping over optional fields. One potentially powerful mechanism for reducing input burden is conspicuously absent from the systems studied -- creation of command files or command macros. This capability is particularly valuable in systems with a heavy emphasis on data query and retrieval, such as IISS. The utility of this design feature in message-handling systems depends heavily on the kinds of uses to which the system is to be put and the likelihood that users/operators will repeatedly perform very similar message entry operations.

3.3 Interrupts and Work Recovery. Little was ascertained in this analysis concerning recovery from catastrophic system failure. Procedures for dealing with these sorts of events were not typically stressed in system documentation.

Where interrupts were caused by anticipatable events, such as movements of the system from one field location to another, provisions for restart seemed adequate. It should be noted, however, that many systems presume the presence of highly skilled system operators for system initialization and startup. This dependency may cause problems in crisis situations.

Both of the message-oriented systems contain provisions for placing completed or partially completed messages in a buffer pending completion of higher-priority activities. Retrieval of these stored messages permits the user-operator to proceed as though no interruption had occurred. IISS also has provisions for storing partially completed JINTACCS messages. As it is currently configured, however, there is a significant problem with the IISS procedure. If a user/operator starts and finishes the creation of a JINTACCS message without interruption, the process is supported by permitting the user/operator to fill out message "blanks." If the process is interrupted, the partially completed message may be stored in a file for subsequent completion. In this case, however, the user/operator can no longer simply fill in a message "blank" -- he or she must type both field labels <u>and</u> entries in the appropriate format.

4.0 Message Composition Aids

4.1 System Design Features. Except for the Automated Run Book of the DS4, all of the systems studied have provisions for sending and receiving at least one kind of message. TCT and TACFIRE are message-oriented systems; their primary purpose is to permit users/operators to easily communicate to other Army personnel within a distributed information network. IISS is primarily a data base oriented system, but includes capabilities for sending and receiving both JINTACCS and analyst-to-analyst messages.

All three of these systems have provisions for sending and receiving two general types of messages: free text messages and highly formatted messages. In TCT and TACFIRE, the free text messages are merely another type of message. In IISS, the USER MSG option is used to send free text analyst-to-analyst messages, while the IN ANAL option is used for generating JINTACCS messages, which are highly formatted.

Techniques for generating messages are similar for all three systems. All use "fill-in-the-blank" method, though the implementation of this method varies somewhat. TCT supports the creation of its messages with data entry menus, while the other two employ direct entry of information into the empty spaces in the forms.

All of the message-handling procedures in the three systems have cursor-oriented editing procedures. Incorrect or undesired values are altered by placing the cursor over the undesired entry and overprinting it. Editing procedures for TCT and IISS are somewhat more convenient, since they protect the field labels of the message data entry formats. In TACFIRE data element labels can be overprinted because the cursor does not skip automatically past these names. Thus a user/operator can change data elements either inadvertently or deliberately by overprinting them, thus causing errors or invalid data base entries.

The greatest deficiency in system design for message composition is the lack of legal values information available for TACFIRE and IISS. If users/operators forget what entries are valid for a particular message element, there is no alternative to consulting hard copy reference materials. These manuals can be easily lost or mislaid, and the positional disparity between printed page, keyboard, and screen can make unnecessarily difficult the transfer of information from the reference manual to the appropriate portion of the message blank. Neither TACFIRE nor IISS contain pointers to portions of hard copy references dealing with individual data elements or particular message types. As indicated above, TCT does not exhibit any of these deficiencies, since it employs menus for message data entry.

4.2 Format for Alphanumeric Messages. The appearance of highly formatted messages is similar for all three systems (recall Figures 28, 29, and 30) which support message composition. TACFIRE's message blanks are somewhat more densely packed than those of the other two systems, probably because of the limited screen size available on its displays. All of the systems use virgules (slashes) to identify subelements of message data entry information; this is a desirable feature. IISS and TACFIRE both indicate the maximum allowable size of the data entry fields by providing "underlines" for each field. TCT does not employ this feature, but it is not nearly so necessary since the menu-oriented message compositon of TCT is not vulnerable to string length errors.

There is one problem with the message formats in all three systems which could cause significant degradation of message output: the rigidity of the formats themselves. If information which is used to generate the messages always arrives in the same format, that format is identical to the appropriate portion of the message blank, there will be no problem. But this is not always the case. Information can be received via either voice or informal (free text) messages. The user/operator must then skip around in the format on the display screen, or else follow the screen format and skip around in the incoming message. Either approach is clumsy, time-consuming, and prone to error.

4.3 Graphic messages. During the period in which data were gathered for this analysis, none of the systems studied had the capability for constructing or receiving graphics messages. This capability is planned for implementation in TCT for early 1981, but no final information on its form is available. The IISS terminals (Sperry-Univac 1652's) have graphics capabilities, but these are not yet used in IISS operations.

5.0 Data Retrieval Assistance

5.1 Query methods. Three of the systems studied have some form of data base query method: DS4 Automated Run Book, TACFIRE, and IISS. TCT is almost wholly message-oriented; as yet, no requirements for data base construction or query have surfaced in TCT development. The query methods for the other three systems are radically different.

The Automated Run Book of DS4 provides the least comprehensive query capability of the three. Since the ARB is essentially a software "front end" used to input or edit data and to create job control language for batch computer runs, it cannot interact directly with the affected files in any truly transactional sense. Its query capabilities are limited, therefore, to generation of predefined, periodic "products."

TACFIRE provides the capability to interrogate the system's data bases through special query messages, which are similar in format to other TACFIRE messages. However, because of the severe size constraints in the system's display screens, if the output from a query is extensive it must either be output in multiple messages on the screen or else output to the printer.

In either event, the relatively low data transmission capabilities of the TACFIRE communication network limit the amount of information that can conveniently be received from a TACFIRE QUERY.

IISS provides the most comprehensive query capability of the three applicable Army battlefield automated systems. This is not surprising, since the core purpose of IISS is to provide for storage and exploitation of ground order-of-battle data. IISS provides two basic query methods:

a. The Man-Machine Interface Selection/Retrieval Screen (Figure 31). This is essentially a fill-in-the-blanks support to GIM queries. "Hits" from this retrieval process are displayed in a preformatted index list (Figure 32); the user/operator can examine in detail any of the records in the "hit" list by light-penning any of the displayed items in the index list.

```
CLASSIFICATION                              ***CAVEAT***

                RETRIEVAL SCREEN FOR AIR UNITS FILE (AUNFF)

IDENTIFIED UNIT(ID)______
UNIDENTIFIED UNIT(ID)______

                                            ORIGN (2)________
+FHSTR(6) ___________
+PRSAT(6) ___________                       ACTYP     ________
 OBTYP(1) ___________                       CALEG (2)________
 ACCND(5) ___________                       RMKEY (5)________
     (76) __________________________________ACFTF(19)________
     (76) ___________________________________________________
PUNIT(76) ___________________________________________________
EXECUTE:__________    INDEX:____________    CONNECTOR:_____

+RANGES ARE PERMITTED (1ST VALUE MIN. 2ND VALUE MAX)
```

Figure 31. Example of a Selection/Retrieval Screen. Redrawn from *IISS User's Manual*, p. 3-41. (Note: not all field labels are included in this figure because the photocopy of the document used for analysis was unreadable.)

b. The GIM language. This is easily the more powerful of the two query methods available in IISS, allowing the user/operator to exploit the ground order-of-battle data base in almost any conceivable way. The GIM language includes command terms for at least four functions.

   1. Verbs indicate to the system what activities are to be performed.

CLASSIFICATION ***CAVEAT***

SHORT OUTPUT SCREEN FOR AIR UNITS (AUNTF)

AUNTF	EQATH	EQPOH	ACFTF	PRTOT	PHTOT	CALEG
AUNITØØØØ2 I AIRUNITØ3	2	49	ACFT	156	Ø	IT
AUNITØØØØ3 I AIRUNITØ4	3	48	ACFT	16Ø	Ø	IT
AUNITØØØØ4 I AIRUNITØ5	4	47	ACFT	164	Ø	IT
AUNITØØØØ6 I AIRUNITØ7	6	45	ACFT	172	Ø	IT
AUNITØØØØ7 I AIRUNITØ8	7	44	ACFT	176	Ø	IT
AUNITØØØØ8 I AIRUNITØ9	8	43	ACFT	18Ø	Ø	IT
AUNITØØØØ9 I AIRUNIT1Ø	9	42	ACFT	184	Ø	IT
AUNITØØØØ1Ø I AIRUNIT11	1Ø	41	ACFT	188	Ø	IT
AUNITØØØØ11 I AIRUNIT12	11	4Ø	ACFT	192	Ø	IT
AUNITØØØØ12 I AIRUNIT13	12	39	ACFT	196	Ø	IT
AUNITØØØØ13 I AIRUNIT14	13	38	ACFT	2ØØ	Ø	IT
AUNITØØØØ14 I IARUNIT15	14	37	ACFT	2Ø4	Ø	IT
AUNITØØØØ15 I AIRUNIT16	15	36	ACFT	2Ø9	Ø	IT
AUNITØØØØ16 I AIRUNIT17	16	35	ACFT	212	Ø	IT

Figure 32. IISS Index List. Redrawn from *IISS User's Manual*, p. 3-41.

2. Qualifiers indicate under what circumstances certain activities are to be performed. Conditional situations may be defined mathematically, list-positionally, logically, or in combinations.

3. System literals identify values (defined as literals) which are necessary for system operation.

4. Connective bridge terms and phrases in GIM commands, defining how they should be combined in order to yield the desired results.

GIM queries are more flexible and powerful than MMJ queries. A user/operator who wishes to fully exploit the capabilities of IISS is therefore forced to learn GIM. This requires the memorization of 137 GIM language terms, the grammatical and syntactical rules for using those terms, and the mnemonics and legal values for the TACOB (or other OB file) record elements. These requirements impose an excessive memory burden on intelligence analysts/users who are not computer specialists.

None of the systems studied employs query files or query macros to permit users/operators to store "canned" queries for subsequent use.

5.2 Query structures. Of the systems studied, only IISS contains sufficiently powerful query capabilities to warrant consideration of query structures. Using either the MMI or GIM language capabilities of IISS, users/operators can define queries in a number of ways:

a. Simple queries, based on single-item specifications in the query. For example, the user/operator might wish to examine the order-of-battle record for a particular enemy unit. By entering the appropriate GIM command and the unit I.D. for that unit, the user/operator can list the contents of the record for only that enemy unit.

b. Conditional queries, formed by combining specified characteristics of a hypothetical unit. Conditions may be specified methematically (e.g., "2ØØØ persons"), relationally (e.g., "more than 2ØØØ persons") or on the basis of string matches (e.g., "equipment type 7-72;" "echelon-regiment;" "alternate name = BIGREDZ"). Logical operators are also permitted (e.g., "all units with more than 2ØØØ persons AND equipment type T-72").

c. Geographic queries, wherein the user/operator defines a geographic region and extracts from the data base all information with specified characteristics from that region. Both circle searches and $\underline{n}$ sided polygon searches ($z < \underline{n} < 14$) are provided.

Combining GIM commands (either directly through GIM language mode or indirectly via the MMI) and characteristics of the data base being queried clearly provides IISS users/operators with a powerful, flexible query mechanism. Query structures possible are therefore only trivially constrained by the available query tools. But this power and flexibility do not come without cost. After deciding what sort of query to perform, the user/operator must define the structure of the data base search and retrieval to be performed. Except for the geographic search capability IISS has virtually no "canned" query structures. This forces its users/operators to learn how to generate their own query structures.

It is perhaps constructive to compare IISS with the Automated Run Book of DS4 with respect to their provision of prestructured queries. The ARB is not nearly so flexible a system as IISS; its users/operators can perform only those activities listed in its command menus. To generate a STOCK STATUS REPORT, for example, the Run Book user/operator merely selects that item from the DSC WEEKLY REPORTS-PROCESSES menu (Figure 33). The report is

```
==============DSC WEEKLY REPORTS-PROCESSES============

0       I need HELP (FUNCTIONAL GUIDANCE)
1       We need to do a WEEKLY CONSOLIDATION
2 (SS)  We need to do a STOCK STATUS REPORT
3       We need to do a WEEKLY REPORTS PROCESS
99      It is time to TERMINATE this session.


  -> Please enter the line number which describes what
     you want to do <-
```

Figure 33. The menu of weekly reports-processes that are presented by the Automated Run Book.

then generated by DS4; rules for selecting, combining, extracting, formatting, and printing the data are supplied by DS4 software. The Run Book user/operator need not be concerned at all with these rules, and the interaction to specify a STOCK STATUS REPORT would take about 15 seconds.

If it is assumed for purposes of illustration that IISS files contained admin/log data like that in DS4, rather than order-of-battle data, the IISS user/operator would have a far more difficult task than would the Run Book user/operator. If no special provisions for creation of a STOCK STATUS REPORT were made, the IISS user/operator would have to:

a. Ascertain what data items would be used in generating a STOCK STATUS REPORT.

b. Ascertain how data items would be combined to yield the information required in a STOCK STATUS REPORT.

c. Identify criteria for including or excluding the contents of individual records from the STOCK STATUS REPORT.

d. Ascertain the required output format for a STOCK STATUS REPORT.

e. Enter GIM commands for both data extraction (query), data processing, and report format.

It is entirely conceivable that this process would require several hours, rather than a few seconds.

It would be inappropriate to conclude from this discussion that IISS is a "bad" system and the DS4 Automated Run Book's a "good" one. The systems are in different functional areas, and are driven by completely different sets of user and functional requirements. Note also that IISS would provide the user/operator with vastly increased flexibility in defining and organizing products. The IISS user/operator could, for example, generate a report identical in format to a STOCK STATUS REPORT, but limited in content to only a certain class of stock items. This would be impossible in the Run Book without substantive modification of the DS4 software.

The comparison of the IISS and Run Book designs does, however, highlight a distinct difference in "query" philosophy:

a. The Run Book places severe constraints on the range of "query" structures permitted.

b. IISS places almost no constraints on the query structures which its users/operators may employ. The number and variety of query products are limited only by the imagination, requirements, and skills of the users/operators. This flexibility extracts a penalty in terms of the time and effort required to describe the characteristics of the required product to the ADP system.

It is possible, even likely, that the operational requirements of order-of-battle data absolutely require the flexibility provided in IISS. It would be appropriate to limit the options provided to experienced user/operator in generating precisely the kinds of queries which he or she desires. Developing and incorporating more "canned" query structures into IISS might, however, yield significant benefits, particularly if say, 10 or 15 such structures would account for a majority of the queries actually made by IISS users/operators. Incorporating these query structures would require investigation of the kinds of activities typically performed by GOB analysts. Such an investigation is beyond the scope of this project, but should be conducted if the thrust of IISS modifications to enhance the usability of the system is to be clarified. Lessons learned in IISS are likely to be transferable to other Army battlefield automated systems.

6. Glossaries

6.1 Standard terms. Terms used in battlefield automated systems should be standard both within and across systems and should conform to doctrinal usage. This statement seems so obvious as to be unworthy of mention. However, both of these maxims are violated--and frequently. TACFIRE presents considerable difficulty with respect to provision of standard terms: 10 volumes are required to describe procedures for using 225 message formats incorporating over 900 data elements, their element names, and legal entries for their names. Just about every problem that could be imagined with standard terms is evident in TACFIRE:

a. Multiple names for the same data element.

b. Different meanings for the same data element name in different messages.

c. Lack of on-line assistance for "decoding" data elements.

d. Similar but slightly different message formats where one constant format, using consistent terms, would do.

e. Functions requiring similar formats labeled just enough differently at different positions to cause confusion (e.g., AFU;BAMOUP for BN and AFU;AMOUPD for DIVARTY).

f. Codes which differ from doctrinal codes (see Figure for examples).

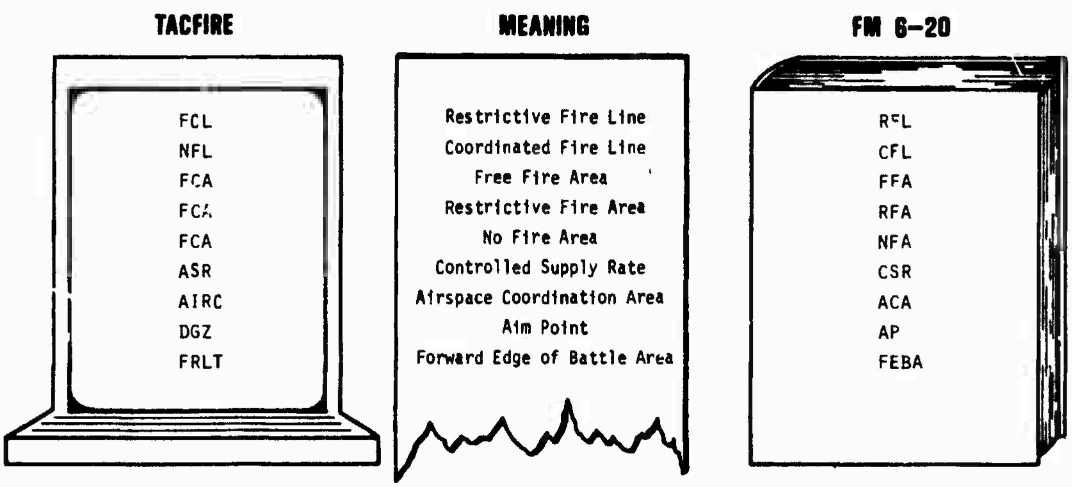

Figure 34. Examples of Differences Between TACFIRE and Doctrinal codes.

The Automated Run Book uses standard terms in its menus and prompts but creates some minor problems by ambiguous use of pronouns and verbs which could contribute to problems for unsophisticated users/operators.

IISS has some good features with respect to standard terms. For example, it automatically calculates and/or inserts data values for geocoordinates, date of update, and position track information when these are available from standard system information. In the main, terminology in the MASTER MENU, the GIM MENU, and the IISS HELP listing is consistent. In general, however, terminology within IISS could have greater consistency--for fixed and variable function key labels, option switches and the record element levels of TACOB data sets. Also, IISS uses at least three separate command methods--the TELETYPE mode, the MMI forms, and the GIM-II language--and there are some instances of completely different terminology within these to designate the same function.

As shown in Figures 7 and 8, systems differ not only in the way in which given functions are accomplished but also in the terminology applied to label such things as function keys or to call out commands when functions are performed in the same manner. Just as users/operators shift from one position to another within a system, they can be expected to shift across systems. Serious penalties can be expected to be paid in terms of retraining, user/operator error, mission delay and even abort when unnecessary inconsistencies in standard terminology are allowed to persist across systems.

6.2 <u>Character sets and labels</u>. Most systems use the 26 letters of the alphabet and the digits 0 through 9 for data entry, although the key arrangements for these data entries may vary considerably across systems and even within systems (see the discussion of this under 1.3 <u>Function Keys</u>). Most systems, in addition, use a set of special symbols as delimiters, commands, or operators. Most of these symbols have a "conventional" meaning that derives from some grammatic or arithmetic convention. Both the set of symbols used and their meaning may vary considerably from system to system--often without apparent reason.

There are at least five problems commonly associated with character sets and labels:

a. Inconsistent usage across systems.

b. Multiple meanings or purposes for a given symbol.

c. Multiple symbols used for the same purpose or meaning.

d. Usage which is outside the bounds of the user's/operator's knowledge/experience.

e. Usage which is not in agreement with "convention."

Figure 9 demonstrates the first type of problem with respect to common non-alphabetical symbols. Note that the colon (:) is used in TACFIRE and TCT as a single-valued field delimiter, while IISS uses the virgule (/) for this purpose (and uses the colon to separate the switch from the switch parameters). Figure 10 demonstrates inconsistent usage of Boolean/relational/logical character sets across systems.

Problems of the second type, multiple meanings or purposes for a given symbol, are also demonstrated in Figure 9. In this respect, TACFIRE and TCT are "cleaner" than the other systems examined and, from the data presented in Figure 9, Army systems in general are better than the non-Army systems examined. IISS uses the virgule (/) as both a field delimiter and as the arithmetic operator for division, however.

A number of examples of the third type of problem are evident in Figures 9 and 10. For example, dates can be written as day (2 digits), time (4 digits), zone (1 letter), month (3 letters), and year (2 digits) in one continuous stream in TCT. Dates can also be written as month (2 digits followed by /), day (2 digits followed by /), and year (2 digits) in MAGIS. MAGIS also uses the virgule (/) to separate hours, minutes, and seconds; as a command prefix; and to separate mnemonics. While these uses are not in conflict with each other, they do make the system and the user/operator lean heavily on one single symbol.

The kinds of problems which result when users/operators are required to use symbology with which they are unfamiliar or with which they lack experience or knowledge have been discussed with respect to the "greater than" and "less than" symbols, (>) and (<) respectively, in the text associated with Figure 10 on page 25. A backwards interpretation of these two symbols is not unusual, even with people who can truly be expected to know better. Erroneous use of Boolean/relational/logical operators can be avoided by replacement with

codes (GT for greater than, LT for less than) as are employed in IISS. In fact, IISS circumvents the whole issues of Boolean/relational/logical symbology by letter code replacements.

One noteworthy example of this type of problem is found in the DS4 Automated Run Book, despite its otherwise relatively standard and acceptable usage of character sets and labels. Here the (@) key is used for backspacing when the user/operator wants to correct a typographical error. Convention tells us that the key symbol for backspacing should be (<—) and that the (@) symbol usually means "at or about," "approximate," or "rate per" but in no way indicates to the user/operator to backspace and correct a typographic error.

6.3 Glossary availability and use. To be of most value, glossaries should be available on-line, should be logically organized for ease of access, and should be available in usable "chunks" and in as many versions as dictated by user/operator requirements.

Glossary availability and use is one category where the review of TACFIRE led to the conclusion that a human factors-related problem could result in system failure. TACFIRE glossaries are contained exclusively in off-line documentation; the computer provides no on-line definitions of data element names and no on-line dictionaries of legal terms. As noted in the discussion of standard terms, there are so many names and terms that no user/operator could reasonably be expected to memorize more than a relatively small percentage of them. To obtain assistance for any term in a message, the user/operator must turn attention from the computer to off-line manuals--and then upon returning to the screen, relocate the area of the screen being attended to. Switching attention between the screen and documents consumes time and increases the likelihood of error. Even more devastating, in a fluid tactical situation, if the off-line documents should be lost, one could easily imagine that a situation might arise in which users/operators would need to enter messages beyond the normal (and presumably well-learned) repertoire. Deprived of their primary job aid--the document--users/operators could only guess at element name definitions and at legal entries. In this event, the system could fail to perform its mission.

IISS provides nine separate terms and code sets which can be considered glossaries. These run a spectrum from always available key labels to never

either event, the accuracy of the data base may be degraded, leading to errors in system outputs. The rate of artillery information processing may be reduced; overall field artillery effectiveness may be reduced.

The Automated Run Book, in general, uses abbreviations and codes in the data reduction function but not in the production processing function. Even in data reduction, abbreviations and codes are used only in data fields of transaction card images. Not using abbreviations and codes has potential for system degradation too, since many codes and abbreviations can quickly become well integrated into user/operator processing routines. As shown in Figure 35, code options which are standard in the supply function are available in the As Required Reports-Process menu; the DS4 user/operators cannot use these codes but instead must use arbitrary number codes.

```
========DS4 AS REQUIRED REPORTS-PROCESSES========

0      I need HELP (FUNCTIONAL GUIDANCE)
1 (AR) We need to do a ASL REPLENISHMENT (STAND ALONE)
2 (LS) We need to do a LOCATION SURVEY PROCESS
3 (MC) We need to do a MASS CANCELLATION PROCESS
4 (PC) We need to do a PARAMETER CHANGE PROCESS
5 (SI) We need to do a SPECIAL INVENTORY
6 (SX) We need to do a SIMS-X PROCESS
7 (UD) We need to do a UNIT DEMAND HISTORY EXTRACTION AND INSERTION PROCESS
8      We need to do a CYCLIC ERROR LIST
9      We need to do a EDIT-ARRANGE ABEND SORT 1
10     We need to do a EDIT-ARRANGE ABEND SORT 2
99     It is time to TERMINATE THIS SESSION

  -> Please enter the line number which describes what you want to do <-
```

Figure 35. The menu for As-Required Reports-Processes in the DS4 Automated Run Book.

available on-line display of such things as legal values. As in TACFIRE, loss of documentation (although probably much less likely than for TACFIRE) could result in grave jeopardy to the mission.

In TCT, on the other hand, standard terms, character sets and labels, glossaries, and abbreviations and codes used in the standard message formats are presented to the user/operator through menus and prompts. Although glossary definitions had not yet been made available at the time of the review of the DS4 Automated Run Book, developer personnel indicated that HELPS to be provided by the Logistics Center (LOGCEN) will include glossary definitions for on-line display.

6.4 Abbreviations and codes. Abbreviations and codes are used extensively in battlefield automated systems: message formats almost always require them. Even the TCT FREE message format uses abbreviations and codes in its heading information. Doubtless, the message text proper will contain abbreviations and codes for the simple reason that military systems are replete with them. In truth, our total language has become one that accepts abbreviations and codes as "words." While computer systems cannot be totally blamed for that situation, they have, nevertheless, contributed to it.

The problem is not that abbreviations and codes are so widely used, but that they are so poorly and so inconsistently designed. The TACFIRE situation is representative of these problems. The TACFIRE glossary contains a mixture of full words (e.g., SPHERE, FUZE), abbreviations (e.g., COORD, FZE), mnemonics (e.g., GZ, DTG), and codes (e.g., D, LINA). Most element names in TACFIRE formatted messages consist of abbreviations, mnemonics, or codes. But no consistent rule for formulating these element names has been found. This lack of consistency complicates the user's/operator's attempts to decode element names and forces the user/operator to decode abbreviations, mnemonics, and codes from memory--or else refer to off-line manuals. Variations in element names (see 6.1 Standard Terms) from one format to another create a distinct possibility for confusion of common elements from message to message. If the user/operator attempts to decode element names from memory, the probability of erroneous decoding is increased. Errors in decoding may lead to erroneous inputs. If the user/operator decodes element names by reference to manuals, time required to complete transactions is increased.

Most IISS code sets employ mnemonic abbreviations. The rules for forming these mnemonic codes are not rigorous although they do seem reasonably logical. There are, however, some exceptions. In the TACOB record element abbreviations, for example, the term "message" is abbreviated in the following ways:

CODE	MEANING
MORIC	Message Origination or Originator
ACMSG	Message
MIDENT	Message Identifier
MGTXT	Message Text

The use of several different methods for creating mnemonic abbreviations results in dissonant habit formation patterns--resulting in an effective memory loading which is much higher than that which would be required to learn a consistently designed set of codes. Inconsistent codes are more difficult to recall, requiring users/operators to access HELP files or refer to IISS documentation. Difficulty in recalling codes is also likely to increase input error rate. The normal difficulty in recalling codes from a large code set is exacerbated by the inconsistency in code sets. With an increased error rate caused by inconsistent codes, delayed delivery of intelligence information to battlefield commanders will result.

Part of the IISS problem with abbreviations and codes is its "richness" of codes. For example, in addition to the multiple codes for "message" shown above, there are the following codes for variations in the meanings of "country" and "equipment":

CODE	MEANING
CCNTY	Country of Control
CALEG	Country of Allegiance
CNTRY	Country of World
COLOC	Country of Location
NCNTY	Country of Nationality

CODE	MEANING
EFUNC	Equipment Function
EQATH	Equipment Authorized
EQPOH	Equipment on Hand
EQTYP	Equipment Type
EUSER	Equipment User

7. Error Handling

7.1 Error prevention techniques. Most battlefield automated systems incorporate features which will prevent user/operator error. Few do enough, but there are some good and even some clever error prevention techniques employed.

The Automated Run Book incorporates some good error prevention techniques. In the production processing function, there is a recap at the end of a menu selection sequence which should reduce the probability of invoking DS4 cycles inappropriately. Its use of menus also reduces errors because they display all legal values and thereby reduce the memory burden on the user. The use of questions to elicit ECL parameter information helps to prevent entering the wrong kind of data. For example, asking for a date relieves the operator of the necessity to remember that Data Field Number 1 requires a date rather than some other type of information. Also, in the data entry mode of the data reduction function, underlines are used to indicate the length of each data field, with each underline being replaced by the input character as data entry proceeds. Indicating field length in this manner is useful in two ways:

a. It cues the user as to the type of data to be entered.

b. If the user inadvertently omits one or more characters, the presence of underlines at the end of the field provides a cue to review the data field and correct the error.

TACFIRE appears to incorporate only one on-line error prevention technique: data element names. However, as noted in 6.1 Standard terms, the sheer volume,

redundancies, and inconsistencies in these element names will degrade rather than enhance user/operator performance.

For TCT, no specific routines for error prevention were identified. However, the availability of legal data entry items via the menus contributes directly to error prevention.

IISS contains a number of techniques designed to prevent errors of command and data input:

a. On both MMI (process control) and full record displays (data entry) the field size indication shows the user unequivocally how many characters can be entered. There is, however, generally no indication of whether this number of characters is the maximum number allowed or the only number allowed.

b. The use of light pens for command and file selection allows the user/operator to select from options which are being viewed directly rather than by reading or recalling commands/data and entering the commands at the terminal keyboard.

c. Presentation of data element labels reduces the memory burdens on users/operators by eliminating the necessity for recall of record element mnemonic labels.

d. Which screen area of the SU 1652 is currently active is indicated to the user/operator. This reduces the probability that data will be entered into an incorrect screen area.

e. Automatic creation of data values such as date and geographic coordinates reduces the burden on the operator. A concomittant effect is reduction of the number of items which the user must enter, thus reducing the opportunity for error.

f. VFK labels are lit when they are active, thus assuring that the user/operator will not waste time or cause an error by pressing VFKs which are not currently available.

g. The presentation of "switch" options on MMI forms assures that the user is constantly presented with all legal values where switch options are available.

h. Any of seven formats can be used for entry of dates. The first of January, 1981 can be entered in any of the following forms.

1. January 1, 1981

2. 1 Jan 1981

3. 1 Jan 81

4. 1-1-81

5. 1/1/81

6. 1 January, 1981

7. 1-Jan-81

This reduces the likelihood of error in date entry, thereby reducing processing time and providing accurate date information in IISS intelligence products.

7.2 Error detection techniques. In terms of detecting errors which are input into the system, the Automated Run Book again incorporates good techniques. By the use of range checks, legal value checks, and cross-field checks wherever possible the probability of errors contaminating the DS4 data base is greatly reduced. In addition, the program checks each field as it is entered, rather than waiting for the entire transaction to be completed before beginning error checking procedures. This feature is particularly good, because it provides an immediate opportunity for the user to correct each error.

Only minimal detection of message entry or system operation error is provided on TCT. The operator alerts which appear on the plasma screen provide indications of invalid entry and identify certain function key operations which should be performed. But both operator and system alerts are more precisely "alerts" than error detection in that they advise about status or what needs to be done.

The GIM DBMS employed in IISS provides a number of capabilities for error detection to maintain data base integrity:

a. The system checks the input to determine whether the character string entered is of appropriate length. GIM can check for both maximum and minimum string length limitations.

b. If input values are to be limited to a small number of predetermined values (e.g., H for high, M for medium, L for low), GIM can test to determine whether the input contains one of these legal values.

c. Where the number of legal values for a record element is large, the GIM software can check the input string against a table of legal values. This technique is used to evaluate country code inputs in IISS, for example.

d. Relational and arithmetic rules are applied to evaluate data entry against other data already contained in the TACOB data set, thereby providing a data validity check.

e. Some data elements in TACOB files can only be entered if a corresponding data element is also entered. For example, when a new location is entered to a EUNITS record, the corresponding "change location date" must also be entered. This assures that the USAREUR analysts will know how current position reports are.

TACFIRE also performs no error checking until a message is completed and entered for processing. Then, it checks the message one field at a time. If an error is detected, an error message is displayed (however, see 7.3 Error feedback) and processing of the message stops. The user/operator corrects the erroneous entry (see Section 7.4 Error correction/recovery), and error checking continues. The machine provides no indication of multiple errors, detecting the next error only after the previous error has been corrected. This procedure is a needless annoyance to the user/operator, and delays the completion of transactions.

7.3 Error feedback techniques. All of the BASs examined were found wanting with respect to error feedback. Error feedback is the weakest aspect of the Automated Run Book's error handling features. In general, the Run Book's error feedback consists of an audible "beep" from the terminal and then a recovery message. But, the recovery message indicates only what are valid entries; it does not tell the user/operator what the incorrect entry was. While making the determination of what the incorrect entry was may not always be difficult, the necessity to make that determination provides another opportunity to commit an error.

TACFIRE error messages in general also contain little or no diagnostic information. To discover the cause of an error, the user/operator must either page back to the error location or read an error code from a panel on the main computer. This code is displayed in binary lights; the user/operator must convert the binary code to octal, and then look up the octal code in a off-line manual to obtain error diagnostics. The machine's error feedback facilities

force the user/operator to divide attention between the display screen, the SPA (to page back) or the binary display, and off-line documents. This procedure consumes time and increases the likelihood of errors. Converting binary to octal provides an additional opportunity for error. Overall system efficiency is reduced as transactions are delayed; the accuracy of the data base is reduced if errors are not detected; and the system's contribution to mission accomplishment is diminished.

Some TACFIRE error messages are reasonably clear and specific, however. For example, if a user/operator attempts to enter 39 as the day of the month in the SYS;INIT message, the error indication "DAY TOO LARGE FOR MONTH" probably will make the nature of the error clear. But, most error messages examined appeared far more cryptic. "AA/AAA ILLEGAL MESSAGE CATEGORY," for example, does not tell the user/operator clearly that a message category was entered that does not match any of the message categories currently stored in the PCLD table. Also, the message does not tell the user/operator the location of the error in the input message.

IISS provides a number of error messages in the message screen area. The list of error messages available during the review of the system includes a number of error and system messages which are not tied to user error *per se*, but which may result from system errors or programming errors. The available documentation is unclear about whether such messages are ever presented to the USAREUR analysts who use IISS. If they are presented, it is not likely that they would be particularly meaningful. The list is apparently not comprehensive, however, since examples of processing contained in the *IISS Data Base User's Guide* list error messages which are not contained in the list examined. In addition, the information content of the IISS error messages is often quite low. The IISS error messages are too vague to permit users/operators to quickly grasp the precise error condition involved. Further, the stilted formal grammar and syntax of the messages make it difficult for the users/operators to interpret the reference of the messages. Difficulty in interpreting the error messages will increase the time required for error detection and subsequent error correction, and delivery of intelligence information to the battlefield commander may be delayed.

No specific diagnostic or instructional information is provided on TCT. Invalid entry of data receives only an "INVALID ENTRY. TRY AGAIN" message. The user/operator is forced to determine why the entry was invalid either through short term memory--recall of which key was pressed--or long term memory--recall of procedural validity trees. Transactions may be delayed while the user/operator diagnoses and corrects the error. There is, further, potential for operator confusion and additional unnecessary system delay.

7.4 Error correction and recovery techniques. Once errors have been detected they must be corrected. The systems examined offer a variety of techniques for recovery from error conditions.

As noted above, TACFIRE error correction begins only after the entire message is completed and entered for processing. For each error, the user/operator must first diagnose the error, retrieve the correct entry from memory of off-line manuals, visually locate the data element containing the error and then position the cursor to the element field using the cursor control keys. In the event of multiple errors, this procedure must be repeated for each error. The procedure is unwieldy and unnecessarily complicates the user's/operator's task. In some cases, a single error may require reentry of several data element fields. For example, to orient the DPM, the user/operator enters into the SPRT;MAP message the coordinates of each of the four corners of the map. However, an error at any point in this procedure requires the user/operator to re-enter all four corners again, even if three of the four are correct. This is an unnecessary source of frustration, imposes unnecessary effort, and requires excessive time to correct errors. In operational situations, delays in orienting the DPM will delay graphic presentation of artillery target intelligence and thereby delay artillery command and control functions. This delay in turn may result in loss of important targets.

Error correction and recovery are handled quite well in the Automated Run Book. The only deficiency noted in this regard was observed in the data reduction function. When the user/operator commits an error during data entry or error correction, a message is presented at the top of the display. This message is not removed from the screen after the user corrects the error: it remains in place until the current transaction is completed. This feature has the following disadvantages:

a. If the user/operator sees the message, corrects the error, and then goes on to enter data in subsequent fields, he or she may look up, see that same message, and try to relate it to the current data field. Thus, the message could be a source of difficulty for the user/operator, and an unnecessary source of frustration as well.

b. If the user/operator commits a subsequent error, the second message merely overprints the first. If the second message is shorter than the first, the remaining "tail" of the first message could in effect change the meaning of the second message, or render the second message uninterpretable.

Once errors have been detected in IISS, they can be corrected in one of two ways:

a. The screen area may be cleared, and the entire statement re-entered.

b. The screen editor and cursor FFKs of the SU 1652 may be used to correct the error in the command or data entry input.

In making error corrections for multi-line commands on IISS, the SU 1652 has pure cursor move commands which allow the user/operator to copy information already on the screen. While copying, the user/operator may also make editing changes to correct errors made in the original entry of the command string. When in GIM-II Language mode, the user/operator may enter several lines of commands before pressing the SEND key to pass the commands to the AN/GYQ-21(V). If there is an error in the command, the user/operator may use the cursor to recopy the command up to the point where the error occurred, correct the error, and then copy the remainder of the command. It can then be transmitted to the central computer for evaluation. As IISS is currently structured, however, the user/operator must make a change in <u>each</u> line of a multi-line command, even when there is no error in that line. Thus, the user/operator is forced to make irrelevant changes to command lines to ensure eventual acceptance of the commands by the system processor. This process wastes time. In addition, the requirement to make at least one change in all lines of a multiple-line command containing an error is easily forgotten, since the procedure is an essentially illogical one.

Correction of errors will take more time than would be required for a better designed error correction procedure. In addition, the probability of multiple errors is increased, since the user/operator may forget the seemingly unnecessary

Requirement to make changes in what appear to be valid command entries. Inexperienced users/operators may not be able to determine why the system refuses to accept seemingly valid commands. Because of increased time to correct errors and the increased likelihood of multiple sequential errors, intelligence information may be delayed in reaching battlefield commanders.

8. User/Operator Configuration

In analyzing various battlefield automated systems, the concept of user/operators had to be restricted considerably. In a very important sense, the commander is the ultimate user of any battlefield automated system, for the obvious reason that he is the unit's ultimate decision-maker and has the ultimate responsibility for the unit. In another important sense, members of the commander's staff are primary, since they generally filter incoming information for the commander in accordance with his guidance. Additionally, other personnel receive and use information generated by battlefield automated systems.

An yet, many of these individuals seldom if ever will interact with these systems. Instead, they use the system indirectly, through subordinate functional personnel who are trained to serve as intermediaries. Although this practice may change in the future as increasing numbers of systems are deployed and more personnel become familiar with them, it seems to be the dominant practice today. Consequently, to limit the analysis to manageable bounds, attention was confined only to personnel who actually interact with the machine directly, or who clearly interact frequently with those personnel. Even so, user/operator configurations ranged from highly complex to very simple. TACFIRE is an example of the former case.

In principle, possible user/operator configurations in TACFIRE are extremely varied. For example, virtually any user or operator can transmit an ATI message to the computer, from which it may go to the intelligence section or to one of the support unit FSEs. Perhaps the most common user/operator configuration is exemplified by the following series of transactions (see Figure 36). The FO (a user) provides information and instructions to the RTO (an operator). The RTO transmits a fire request on the DMD. The request is received on the ACC RD at the cannon battalion where the ACCO (an operator) transmits it to the computer. After processing, the computer displays battery firing data,

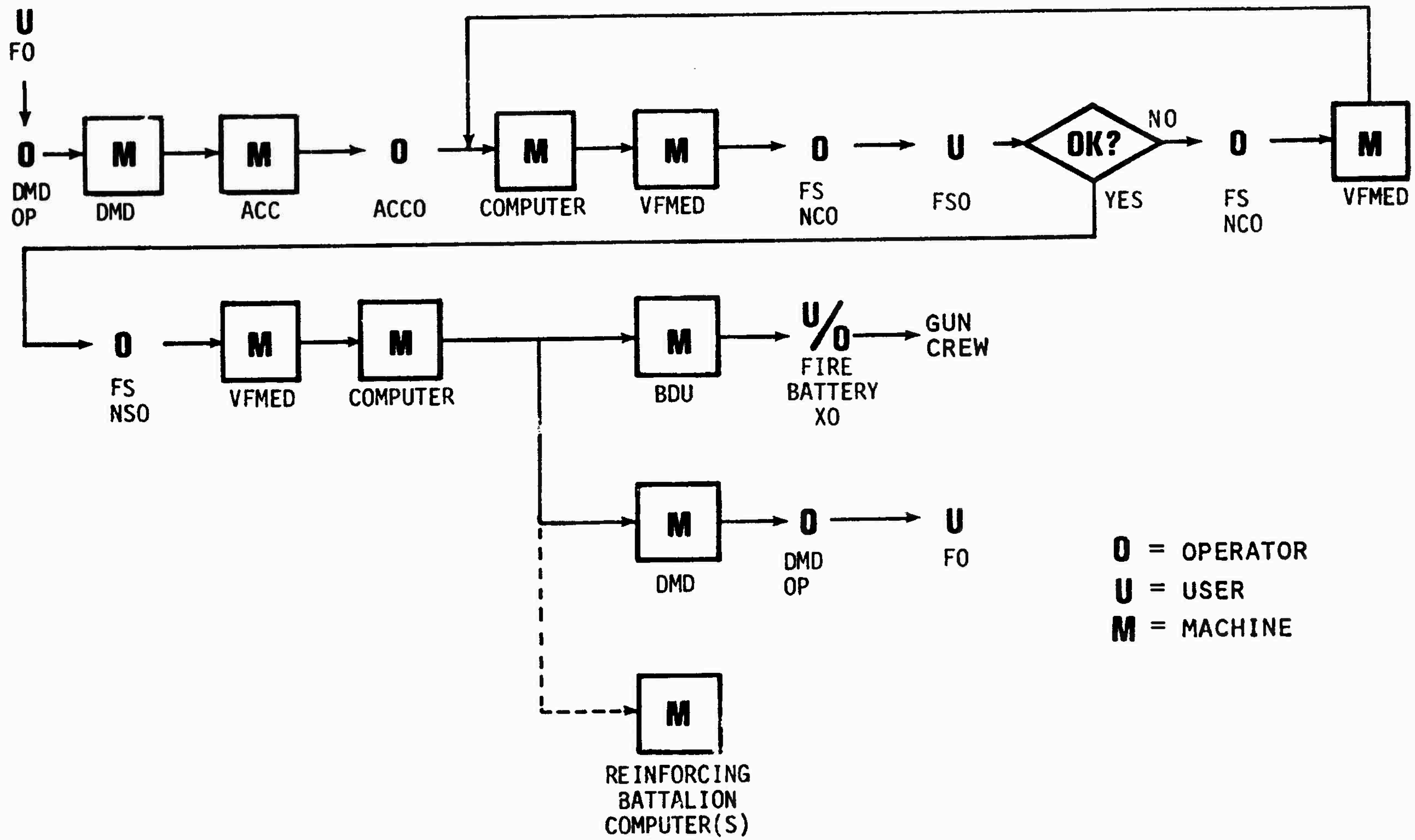

Figure 36. User/Operator Configuration for a Typical Series of TACFIRE Transactions.

any error and warning messages, and if the selected batteries cannot provide sufficient fire, request for additional fire (RFAF) messages directed to other cannon battalions or to the FA brigade. These messages are transmitted automatically to the VFMED (operated by the fire support NCO) at the support unit's FSE, where they are reviewed by the FSO (a user). The FSC can cancel the fire mission, approve it as computed, or modify any or all parts of the mission. If the mission is modified, new firing data are computed and presented on the VFMED for review. When the FSO approves the mission, either as originally computed or as modified, the fire support sergeant presses a transmit switch. The firing data are then transmitted automatically to the appropriate battery BDU's, where the battery executive officer (XO--a user/operator) relays them to gun crews. RFAF messages are transmitted automatically to the appropriate cannon battalion computers, and a message to observer (MTO) is transmitted automatically to the RTO who relays the information to the FO.

Little information has been available regarding TCT user/operator configurations. Clearly, however, the TCT with its two communication channels will have many fewer interaction possibilities than will the TCS with its sixteen channels. In a recent operational test, one TCT at the level of corps was connected to two other TCTs at subordinate echelons, providing a simple tree structure arrangement. Presumably, this structure could be extended as desired, with each TCT at one level connected to two below it.

Probably, however, TCTs in general will be connected to TCSs as the system evolves, so that the greater storage capacity and computational power of the larger machine will be available to a larger user/operator community. In addition, the assumption seems reasonable that TCSs will be interconnected, and that some TCTs will gain access to TCSs through other, intermediate, TCTs.

If these speculations are valid, then one can expect quite complex user/operator configurations to emerge as the system continues to evolve. Interactions among the members of these configurations, with personnel of varying functional areas, grades, and skill levels, could well become a source of degradation in overall system performance. Thus, while little of substance can be said about this topic at present, it is one that should be considered carefully during planning for future steps in system evolution.

a. USAREUR HQ GOB analysts.

b. CORPS-level GOB analysts.

c. Intelligence Support Element (ISE) personnel.

d. IISS system operator personnel.

e. G2 command personnel.

The first three types are essentially similar. The USAREUR HQ GOB analysts perform all of the TACOB (or other GOB file updates), while the Corps-level and ISE users typically perform only retrievals. Restrictions on user activity are easily controlled by system personnel, so it is not inaccurate to consider the first three types as essentially identical.

The review did not evaluate the role of the IISS system operator personnel. During on-site observations, these personnel were primarily supporting the operations of the analyst-users. There was insufficient time to perform adequate analyses of both classes of "hands-on" users/operators; reviewing analyst/system interface was selected as being of higher priority. Ignoring the role of the IISS system personnel, there are essentially two user/operator configurations which are important in IISS operations:

a. GOB analysts operating autonomously. There are many tasks which the GOB analysts will perform with little or no supervision from or coordination with G2 command personnel. Most of the data base updates, for instance, can only be performed by the GOB analysts themselves. A complete and up-to-date data base is critical to the overall utility of IISS. Updating it is in essence a "background-mode" operation: updates must be performed when time is available and when critical retrievals are not required by command personnel.

b. GOB analysts operating under direct supervision of G2 personnel. Particularly during crisis periods battlefield-echelon intelligence officers will be attempting to collect, coordinate, and analyze intelligence of direct relevance to combat commanders. Since IISS will be a significant resource for order-of-battle information, it is likely that intelligence officers will be interacting directly and frequently with IISS GOB operator/analysts.

The DAS 3 computer will be operated by a system operator. The operator's interactions with functional users evidently will be minimal, particularly in regard to performing tasks related to the Automated Run Book and DS4.

Two users will be able to interact with the Automated Run Book at a time, one from each user terminal. However, each will be concerned with particular tasks, which will not necessarily be related to each other. Therefore, little interaction can be expected to occur between the users during DS4 operations.

CONCLUSION

The results presented above support two conclusions: (1) battlefield automated systems are highly variable on a wide range of attributes related to user/operator transactions; and (2) while examples of good design appear in some of the newer systems, in general battlefield automated systems are characterized by design features that are incompatible with human capabilities and limitations.

Differences Among Systems

That battlefield automated systems should differ among themselves is neither particularly surprising, nor on the face of it especially profound. After all, the systems analyzed in this project are designed for different purposes, in support of different Army functional areas, to process different data types, and for sometimes radically different data processing tasks. Thus, there is no intrinsic reason why they all should have identical characteristics. Nonetheless, many of the features related to human-computer interaction differ without apparent justification.

For example, there is no intrinsic reason to use command language to perform a function on one system, function keys to perform the same function on another system, and menus to perform that function on still another system. There is no intrinsic reason to employ "standard" keyboards on which the locations of commonly used non-alphabetic characters such as "*," "/," ";," and ":" are located differently from one system to the next. If, say, a function key is used to clear the display screen, there is no intrinsic reason to label that key "ERASE" on one system and "CLEAR SCRN" on another system. There is no intrinsic reason, either, to locate the "TAB" key in three different places or three different systems. Nor is there any intrinsic reason to use a format selection matrix on one system to specify a file or other set of information to work on, to use a menu for that purpose on another system, and a command language for the same purpose on a third system.

Differences such as these pervade battlefield automated systems. They result from differing design philosophies on the part of vendors and from differing human-computer interface specifications on the part of proponents and developers. As noted earlier in this report, systems are developed largely in

isolation, with little or no coordination or information exchange among development projects. Thus, lessons learned from one system seldom are passed on to new systems, and problems encountered in the past must be solved anew in the present or future.

The differences among systems have several consequences. For example, stocks of spare parts must be maintained for all the different machines employed in the diverse systems. In addition, maintenance personnel must be trained or retrained each time a new system is introduced. More importantly from the point of view of this project is the impact of system differences on user/operator personnel. These differences might not be important to this group if they were assigned to one particular component of one particular system and then remained there throughout their Army careers. But soldiers do not stay in one place throughout their careers. They move from post to post, from echelon to echelon, from duty assignment to duty assignment--and increasingly from battlefield automated system to battlefield automated system. And each time they encounter a new system, they also encounter a whole new learning experience.

Part of that new experience is unavoidable, of course; the user/operator necessarily must learn those functions and procedures that are unique to the new system. Even so, much of the new learning _is_ avoidable--or could be. For the newly-assigned user/operator must learn to recognize and use, among other differences:

a. New locations and labels for function keys.

b. New meanings, uses, and locations for special character keys.

c. New display formats.

d. New terminology for familiar objects or concepts.

e. New procedures for performing familiar data processing tasks.

These and other differences combine to make each new system a unique experience for the user/operator. They thus impose a necessity for training which contributes nothing to developing greater expertise in the functional area, but merely contributes to making a functional area soldier a better computer operator. Ironically, it is the skilled, experienced individual who is most adversely affected. Whereas experience ordinarily leads to improved performance, in such situations it can actually lead to degraded performance

for some non-trivial period of time. For the experienced user/operator must not merely learn the skills required by the "new" system, but also unlearn the skills that produced effective performance on the "old" system.

Human-Computer Incompatibilities

Examples of human-computer incompatibilities emerged in abundance from the analysis of systems described above. These examples ranged from a set of message format and data field labels so extensive that the user's manual required ten volumes, to a command language set so complex that the system's users/operators were not even aware of the scope of its capabilities, much less able to use those capabilities to maximum effectiveness. Most of the deficiencies observed during the analysis were not so dramatic as these, of course, nor so pernicious. Considered individually, most deficiencies were minor; many were even trivial. Viewed in isolation, most seem hardly worthy of mention, much less any great effort or expense to rectify. But viewing these deficiencies in isolation is most assuredly the wrong way to view them.

For the fact is that, while a proponent, developer, or design engineer may view deficiencies in the human-computer interface individually, the user/operator is not permitted that luxury. In practice, during system operations, design deficiencies appear rapidly in sequence or even simultaneously. For example, an individual may commit an error because of inadequate information about legal entries, encounter a mysteriously coded error message that provides little meaningly diagnostic information once decoded, and then be forced into a confusing recovery routine. In such cases, design deficiencies become something more than unimportant idiosyncracies of the system; they become significant obstacles to smooth, efficient, productive performance. If enough of these deficiencies make themselves felt at one time, they may literally overwhelm the user/operator, particularly during periods of stress.

These cumulative effects of otherwise minor or even trivial design deficiencies impose excessive demands on human perception, memory, intellectual processes, and in some cases perhaps even motor capabilities. As a consequence, many battlefield automated systems demand higher skill levels than anticipated by their developers. In addition, as with differences between systems, time and effort must be devoted to learning a system's peculiarities that would be better spent in developing greater expertise in the functional area of system supports.

Once again, most of this training does nothing to develop a better-qualified functional area soldier, but instead goes to develop a better computer operator.

At an In Progress Review midway through the first phase of this project, the speaker reviewed early results from the analysis of battlefield automated systems. He outlined the consequences of differences among systems and of design features incompatible with human characteristics as discussed above. Then, he posed the following questions, only half humorously.

> Who are the villains?
> Who gets blamed?
> Whose backside gets kicked?
> Whose name gets taken?

The speaker concluded that in reality there are no villains. He argued that system proponents are eager to specify rational, meaningful user requirements. He suggested that developers are more than willing to meet the requirements stated by proponents. He maintained that vendors are anxious to meet the design specifications written by developers. The problem, he claimed, is the process, not the people.

That is, proponents lack the tools to describe user requirements with clarity and precision. Developers lack the tools to translate user requirements into specific, detailed design specifications. Vendors lack the tools to convert design specifications into properly designed and engineered human-computer interface hardware and software. As a consequence, the user/operator encounters a system which may well be optimal from economic, engineering, and programming points of view. Too often, however, the system is anything but optimal from the user's/operator's point of view.

The fundamental problem, then, is that today *there is no adequate human factors technology for the design of user/operator transactions that is readily available to the people who specify, develop, and build battlefield automated systems*. A major goal of this project is to begin development of that technology.

Results of the initial phase of this project suggest conclusions concerning design guidelines and evaluation criteria in the following five main areas:

1. Relationship of guidelines and criteria to Transaction Feature Analysis.

2. Differentiation of guidelines and criteria.

3. Relationship of criteria to the body of behavioral knowledge and methodology.

4. The differentiated state of knowledge concerning the criterial sub-domains of speed and accuracy.

5. The potential synergistic impact of simultaneous presentation of guidelines and criteria.

Transaction Feature Analysis

Considerations of evaluation criteria are pervasive and inherent in any effort to identify and assess the qualities of design features. The relevance and effectiveness of these features are almost always judged on the basis of their apparent impact on transaction speed and/or accuracy. Consequently, delineations of both design guidelines and criteria derive rather directly from transactional feature analysis.

Criteria Versus Guidelines

The concepts of design guidelines and of evaluation criteria are neither simple nor undimensional. Further, their differentiation is complicated by intimate functional relationships. In general:

1. Design guidelines:

   a. Imply what to design into the system.

   b. How to accomplish effective design.

2. Evaluation criteria:

   a. Imply what to evaluate about observed or anticipated transaction performance.

   b. Suggest why transaction design effort is worth effort.

Behavioral Knowledge and Methods

Criteria derive relatively productively from a conventional behavioral framework (e.g., perception, memory, intellectual processing, action, feedback) imposed on each principal area of transaction design. Consequently, the structure of extant behavioral research results should be consistent with requirements for criterial data. Also, productive new research should be achievable using relatively conventional methods. The problem is to bound the behavioral context by the same constraints that will bound design decisions and system testing.

Speed Versus Accuracy

The criteria domain must simultaneously deal with the sub-domains of performance speed and accuracy. This simultaneity requirement is driven by:

1. Tradeoffs between the two domains.

2. Regions of joint optima which shift from one transaction category to another.

The criterial domain is further complicated, currently, by differing amenability of the two sub-domains to behavioral differentiation. That is, in general:

1. Existing data, behavioral models, and research methods permit productive differentiation of errors by behavioral categories.

2. Current data, behavioral models, and research methods do not permit very cost effective partitioning of total transaction time into behavioral components.

Guideline and Criterion Presentation

We can see productive synergism deriving from simultaneous presentation of guideline and criterion information. This is because such simultaneous information presentation would permit the designer to consider as a coherent set:

1. The principal design alternatives currently available.

2. The probable impact of alternative design routes.

3. The nature of performance tradeoffs implied by different design alternatives.

Structure of Provisional Guidelines and Criteria

Information about the problems and deficiencies in the human-computer interface provided a "real world" orientation for the development of guidelines and criteria. This orientation, coupled with considerations outlined above, determined the essential characteristics of design guidelines and criteria. Then, following the format of Table 4 in this document, these characteristics were described in terms of each category and subcategory listed in the table. These descriptions indicate the direction of further guideline and criteria development for the prototype handbook that will be

produced during the project's second phase. For each subcategory listed in the table, discussions were organized in four topical areas:

1. AREAS OF APPLICATION: suggests the situations in which design methods in the category might be applied.

2. METHODS: lists the specific design methods which might be used to provide the interactive capabilities implied by the category title.

3. FACTORS INFLUENCING APPLICABILITY: identifies conditions and situations which affect the selection of particular design methods.

4. CRITERION AREAS: describe the ways in which design methods would affect user/operating performance in interacting with Army battlefield automated systems.

In addition, three sets of provisional guidelines were generated to exemplify the prototype handbook:

1. Areas 1.1 through 1.4: Command Methods for Alphanumeric Terminals.

2. Area 2.4: Selective Highlighting.

3. Area 3.1: Information on Legal Entries.

These guideline sets are organized as follows:

1. DEFINITION: specifies the role of the design feature in human-computer interaction.

2. USE: indicates why a design feature in the category might be used to enhance user/operator performance with battlefield automated systems.

3. APPLICATIONS: describes some of the important situations in which the design feature might be employed. Each application description includes an example of processes which might be encountered in Army battlefield automated systems.

4. TYPES: describes the ways in which particular design methods might be applied to user/operator interaction with Army battlefield automated systems. Where appropriate, examples of these design methods are provided. The examples reflect implementations which might actually appear in battlefield automated systems.

5. RECOMMENDATIONS: presents recommendations for the situations in which design methods should be employed in particular application areas. Recommendations are presented in tables which

rate methods with respect to their general utility in the applications listed.

6. ADVISORY COMMENTS: discuss special factors which affect the utility of particular design methods in particular applications or under special circumstances. Environmental, system hardware, system software, and other factors which might influence the success of the implementation of the method are discussed.

Volume IV of this report presents these materials in detail. Therefore, they are not discussed further in this volume.

PROBLEMS AND DEFICIENCIES

The nature of the problems and deficiencies in battlefield automated systems became apparent during the analysis described above. As noted earlier, the fundamental problem is the lack of an adequate human factors technology for the design of user/operator transactions. This leads to poor design within systems from the user's/operator's point of view and to unnecessary differences in functionally similar design features from one system to another. The result is a need for unnecessarily stringent skill requirements and for unnecessarily extensive training merely to make a computer operator of a functional person.

The nature of the problems and deficiencies in the human factors technology became apparent during preparation of the provisional guidelines and criteria described briefly above and presented in greater detail in Volume IV. Where possible, guidelines were developed on the basis of published research results. The literature containing these results is summarized in Volume V of this report. Where the published research failed to resolve an issue--or failed even to address an issue--the guidelines and criteria were based on the best judgments of personnel experienced in the human factors of interface design. Unfortunately, best judgment was used far more often than research results. As an example of the inadequacies of the literature from this project's viewpoint, consider the following discussion of user/operator configurations (topic number 8 in Table 4).

Assuring success in the design and use of battlefield automated systems depends heavily upon knowledge about a system's user/operator configuration

as well as its human-machine interface. A major obstacle to focusing attention successfully on the user/operator configuration is the general lack of fundamental information about behaviors associated with the interface. The Army, and the military establishment in general, have explored team training and team performance (frequently referred to as "crew" training and performance) in many ways and under many conditions. Despite these efforts, little is known about the personal dynamics of team performance. Even if these team situations were fully understood, there are enough differences between them and typical battlefield automated information systems situations to warrant the data considerably less than fully applicable. Some of these differences are:

a. Most team training performance investigations have centered on situations related to a physical output, e.g., firing a missile or maneuvering a tank. Battlefield automated systems may indeed support these same missions, but the typical user/operator will be more remote from the scene. There may be no product available to the user/operator other than a perishable screen image.

b. The battlefield automated system "team" very often will not be colocated; interactions, even crucial interactions, frequently will occur between total strangers rather than between people who have trained, worked, and played together.

c. The BAS user/operator probably develops a more "kindred" feeling toward the computer than does the ordinary instrument user about those instruments. The fluidity of the system tends to generate such a "personal" relationship. Some systems even promote a kind of identification with the system. The Automated Run Book's master menu display, for example, begins with, "Hello! I am DS4 and I am ready..." with the "I" referring to the system.

d. Menus and commands place the user/operator in the situation of carrying on a dialogue with an inanimate object. In addition, anthropomorphism such as described above may cause negative reactions on the part of some users/operators.

To provide guidelines and criteria applicable to the user/operator configuration found in battlefield automated systems, answers are required to questions such as the following:

a. What are the performance effects of colocated users/operators who can communicate directly with each other, versus those who are separated physically and only communicate electronically through radio, telephone, or screen images?

b. How do the tasks and behaviors of functional personnel in the battlefield automated system differ from those of functional personnel in the corresponding manual systems?

c. How do group dynamics differ between colocated and separated users/operators in a system?

d. Are different types of human-computer interaction (e.g., command language, menu, fill-in-the-blanks) appropriate for different types of users/operators (e.g., personality, experience)?

e. How "friendly" should a computer be to its users/operators (e.g, "Hello! I am DS4 and..." versus "Please choose what you want to do from the following menu" versus "Enter menu selection")?

f. Are user-user interactions as important to overall system performance as user-computer interactions?

Questions such as the above arise in every category listed in Table 4. Other questions of a more general nature also arise. For example, in what ways do individual design deficiencies accumulate to degrade user/operator performance? Which combinations of deficiencies are most harmful to effective performance? What are the effects of design deficiencies on user acceptance of the system? On user/operator morale? Which types of deficiencies have have the greatest impact on performance? On user acceptance? On morale?

Guidelines and criteria can be developed on the basis of expert judgment, at least initially. These prototype guidelines and criteria will have served a useful purpose even if they are not all-inclusive and not entirely correct and accurate--if they encourage a measure of consistency in the design of user/operator transactions. They will have served an equally useful purpose if they generate controversy in the academic human factors community. For if that controversy arises, then perhaps researchers will undertake controlled experimental investigations of the guidelines. Those investigations would provide substantial benefit to proponents, developers, and builders. Because, while the crucible of real world system development ultimately will refine and validate guidelines--and indeed must of necessity provide the ultimate refinement and validation--a systematic, guideline/criteria-oriented program of research would accelerate this effort tremendously.

APPENDICES

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APPENDIX A

TYPES AND AMOUNTS OF INFORMATION OBTAINED FROM REVIEWS OF BAMP SYSTEM SYNOPSES

Key	
⊡	= N/A
☐	= No information
◩ (/)	= Reference, but no substance
☒ (X)	= Useful but incomplete data
■	= Complete information

INFORMATION TYPE	AGTELIS	AIDATS	AMS	APPSII	ARTINS	ATRN	BSTAR	CAS ECM	CASS	CASETOS	CEFLY LANCER	COMFAC	CS3	DAS3	DAMMS	DLOGS	DSU/GSU MLS	DS4	DTOS
SYSTEM ARCHITECTURE																			
o Graphic Portrayal																			
o Functional Relationships																		X	
o Information Flows																			
Type																			
o Voice	X																		
o Digital	X											/						/	
o Hard Copy																		/	
o Magnetic Transportable	X																	/	
o Other																		/	
Format																			
o Free																			
o Semi-Formattec																			
o Formatted																			
SYSTEM COMPONENTS																			
o Subsystem Elements																			
Functions																		X	
Allocation Information																			
SYSTEM FUNCTIONS																			
o Input	/							/			/			/				X	
o Processing	/							/			/			/				X	
o Output	/							/			/			/				X	
SYSTEM INPUTS																			
o Functions Requiring External Data																		/	
o Characteristics of External Data																			
Timeliness																			
Accuracy																			
Format																			
Reliability																			
Volume																			

SYSTEM

Key	
[dot in box]	= N/A
[empty box]	= No information
/	= Reference, but no substance
X	= Useful but incomplete data
[filled box]	= Complete information

SYSTEM

INFORMATION TYPE	AGTELIS	AIDATS	AMS	APPSII	ARTINS	ATRN	BSTAR	CAS ECM	CASS	CASETOS	CEFLY LANCER	COMFAC	CS3	DAS3	DAMMS	DLOGS	DSU/GSU MLS	DS4	DTOS
Frequency																			
SYSTEM OUTPUTS																			
o Type of Information	/							/				/						/	
o Users of Information	/																	/	
o Required Characteristics of Information												/						/	
INFORMATION TRANSFER MEDIA CONTINUITY																			
OF OPERATIONS																			
o Mission	/							/				/		/					
o Degraded Mode Processing Priority																			
o I/O Redundancy	/							/				X		/				/	
o Alternative Data Access Methods	/							/						/				/	
HUMAN FACTORS																			
o Error Minimization																			
o Self Test Capabilities												X							
o Modular Parts Replacement																			
o Component Mobility																			
o File Protection (from users)																			
o Control Characteristics																			
o Operator Prompting																			
SECURITY																			
o Clearances Required	/							/				X						/	
o Identification of Users & Terminals																			
o Identifier Codes																			
o Access Rights to Data Base														/				/	
o Classification of Data Elements																			
STANDARDIZATION																			
o Data Element Dictionary (DED)														X				/	
o JINTACCS Conformance																			
o Message Formats																			
o Deviations from Standards																			

Key

- ⊡ = N/A
- ☐ = No information
- / = Reference, but no substance
- X = Useful but incomplete data
- ■ = Complete information

SYSTEM

INFORMATION TYPE	AGTELIS	AIDATS	AMS	APPS II	ARTINS	ATRN	BSTAR	CAS ECM	CASS	CASETOS	CEFLY LANCER	COMFAC	CS3	DAS3	DAMMS	DLOGS	DSU/GSU MLS	DS4	DTOS
THREAT																			
o Speed of Threat Evolution	X							X											
o Class of Threat	■							■				/							
o Probable Operating Contest	X							■											
COMMANDERS MISSIDN AND FUNCTION																			
o Information Required																		/	
o Timeliness Required																			
PRECURSOR SYSTEMS																			
o Type																		X	
o Employment																		X	
o Sources of Data																		X	
SHORTFALLS ADDRESSED																			
o Type of Shortfall	■							■				■		■				■	
o Impact of Shortfall																		X	
o Priority Rankir	■							■				■		■				■	
TERRAIN AND CLIMATE DATA																			
TRAINING																			
o Type	/													/					
o Amount																		X	
PERSONNEL																			
o Quantitative	/							/				X		X				X	
o Qualitative														/					

Key	
• (dot in box)	= N/A
(empty box)	= No information
/	= Reference, but no substance
X	= Useful but incomplete data
■	= Complete information

INFORMATION TYPE	ELOCARS	ELS	FAALS	FAAR	FAMAS	GPS	GUARDRAIL	IISS	JACS	JTIDS	MAGIIC	MEDREG	MFFASAF	MRM	MILTEWS	MSF	NBDS	NCR 500	PADS
SYSTEM ARCHITECTURE																			
o Graphic Portrayal																			
o Functional Relationships											/				X				X
o Information Flows																			
Type																			
o Voice							/	/			/				/		/		
o Digital							/	/			/						/		/
o Hard Copy								/							/				
o Magnetic Transportable								/			/				/				
o Other								/							/				/
Format																			
o Free																			
o Semi-Formatted																			
o Formatted								/											
SYSTEM COMPONENTS																			
o Subsystem Elements																			
Functions																			
Allocation Information																			
SYSTEM FUNCTIONS																			
o Input							/	/			/				X		/		/
o Processing							X	/			/				X		/		/
o Output							/	/			/				X		/		/
SYSTEM INPUTS																			
o Functions Requiring External Data																			
o Characteristics of External Data																			
Timeliness																			
Accuracy																			
Format																			
Reliability																			
Volume																			

Key

- = N/A
- = No information
- = Reference, but no substance
- = Useful but incomplete data
- = Complete information

INFORMATION TYPE	ELOCARS	ELS	FAALS	FAAR	FAMAS	GPS	GUARDRAIL	IISS	JACS	JTIDS	MAGIC	MEDREG	MPFASAF	MRM	MULTEWS	MSE	NBDS	NCR 500	PADS
Frequency																			
SYSTEM OUTPUTS																			
o Type of Information																			
o Users of Information																			
o Required Characteristics of Information																			
INFORMATION TRANSFER MEDIA CONTINUITY																			
OF OPERATIONS																			
o Mission																			
o Degraded Mode Processing Priority																			
o I/O Redundancy																			
o Alternative Data Access Methods																			
HUMAN FACTORS																			
o Error Minimization																			
o Self Test Capabilities																			
o Modular Parts Replacement																			
o Component Mobility																			
o File Protection (from users)																			
o Control Characteristics																			
o Operator Prompting																			
SECURITY																			
o Clearances Required																			
o Identification of Users & Terminals																			
o Identifier Codes																			
o Access Rights to Data Base																			
o Classification of Data Elements																			
STANDARDIZATION																			
o Data Element Dictionary (DED)																			
o JINTACCS Conformance																			
o Message Formats																			
o Deviations from Standards																			

Key

- [•] = N/A
- [ ] = No information
- [/] = Reference, but no substance
- [X] = Useful but incomplete data
- ■ = Complete information

INFORMATION TYPE	ELOCARS	ELS	FAALS	FAAR	FAMAS	GPS	GUARDRAIL	IISS	JACS	JTIDS	MAGIIC	MEDREG	MPFASAF	MRM	MULTEWS	MSE	NBDS	NCB 5.0	PADS
THREAT																			
o Speed of Threat Evolution							/	/							X		X		/
o Class of Threat		/					X	/			/				/		■		/
o Probably Operating Context							X	X			/				X		X		X
COMMANDERS MISSION AND FUNCTION																			
o Information Required								/											/
o Timeliness Required								/											/
PRECURSOR SYSTEMS																			
o Type																			/
o Employment																			/
o Sources of Data																			/
SHORTFALLS ADDRESSED																			
o Type of Shortfall							■	■			■				■		■		■
o Impact of Shortfall							X								X				X
o Priority Ranking							■				■				■		■		■
TERRAIN AND CLIMATE DATA																			/
TRAINING																			
o Type																			
o Amount							/	■			/								■
PERSONNEL																			
o Quantitative							X	■			■				■				■
o Qualitative							/	■			/				■				/

Key

- ● = N/A
- ☐ = No information
- / = Reference, but no substance
- X = Useful but incomplete data
- ■ = Complete information

INFORMATION TYPE	PAR	PATRIOT	PLRS	QUICK FIX	QUICKLOOK II	RAWS	REMBASS	REMIDS	RPV	SAAS	SAILS	SAMS	SCCS-F	SIDPERS	SOTAS	STANFINS	STARCIPS	TACELIS	TACFIRE
SYSTEM ARCHITECTURE																			
o Graphic Portrayal																			
o Functional Relationships					/				/	X								/	
o Information Flows																			
Type																			
o Voice																			
o Digital					X				X									/	
o Hard Copy										/									
o Magnetic Transportable										/									
o Other									X	/									
Format																			
o Free																			
o Semi-Formatted																			
o Formatted																			
SYSTEM COMPONENTS																			
o Subsystem Elements																			
Functions					X					X									
Allocation Information																			
SYSTEM FUNCTIONS																			
o Input					/					/								/	
o Processing										/									
o Output					/					/									
SYSTEM INPUTS																			
o Functions Requiring External Data										/									
o Characteristics of External Data																			
Timeliness										/									
Accuracy																			
Format																			
Reliability																			
Volume																			
Frequency										/									

Key

- = N/A
- = No information
- = Reference, but no substance
- = Useful but incomplete data
- = Complete information

INFORMATION TYPE	PAR	PATRIOT	PLRS	QUICK FIX	QUICKLOOK II	RAWS	REMBASS	REMIDS	RPV	SAAS	SAILS	SAMS	SCCS-F	SIDPERS	SOTAS	STANFINS	STARCIPS	TACELIS	TACFIRE
Frequency																			
SYSTEM OUTPUTS																			
o Type of Information																			
o Users of Information																			
o Required Characteristics of Information																			
INFORMATION TRANSFER MEDIA CONTINUITY																			
OF OPERATIONS																			
o Mission																			
o Degraded Mode Processing Priority																			
o I/O Redundancy																			
o Alternative Data Access Methods																			
HUMAN FACTORS																			
o Error Minimization																			
o Self Test Capabilities																			
o Modular Parts Replacement																			
o Component Mobility																			
o File Protection (from users)																			
o Control Characteristics																			
o Operator Prompting																			
SECURITY																			
o Clearances Required																			
o Identification of Users & Terminals																			
o Identifier Codes																			
o Access Rights to Data Base																			
o Classification of Data Elements																			
STANDARDIZATION																			
o Data Element Dictionary (DED)																			
o JINTACCS Conformance																			
o Message Formats																			
o Deviations from Standards																			

Key

- ■ (box with dot) = N/A
- □ = No information
- / = Reference, but no substance
- X = Useful but incomplete data
- ■ (solid black) = Complete information

INFORMATION TYPE	PAR	PATRIOT	PLRS	QUICK FIX	QUICKLOOK II	RAWS	REMBASS	REMIDS	RPV	SAAS	SAILS	SAMS	SCCS-F	SIDPERS	SOTAS	STANFINS	STARCIPS	TACELIS	TACJAM
THREAT																			
o Speed of Threat Evolution					X														X
o Class of Threat					■				/	/								■	■
o Probably Operating Context					X				X	X								X	X
COMMANDERS MISSION AND FUNCTION																			
o Information Required					/														
o Timeliness Required					/														
PRECURSOR SYSTEMS																			
o Type										/									
o Employment										/									
o Sources of Data										/									
SHORTFALLS ADDRESSED																			
o Type of Shortfall					■				■	■								■	
o Impact of Shortfall									X	X									
o Priority Ranking					■				■	■								■	
TERRAIN AND CLIMATE DATA																			
TRAINING																			
o Type																			
o Amount					/				■	■									
PERSONNEL																			
o Quantitative					X				■	■								X	
o Qulitative					/				■										

Key

- [•] = N/A
- [ ] = No information
- [/] = Reference, but no substance
- [X] = Useful but incomplete data
- [■] = Complete information

INFORMATION TYPE	TACJAM	TCC-39	TCS/TCT	TNS-10	TPQ-36	TPQ-37	TSQ-73	TUFMIS	TYC-13	TRAILBLAZER	U/E ECM
SYSTEM ARCHITECTURE											
o Graphic Portrayal											
o Functional Relationships											
o Information Flows											
Type											
o Voice							/			X	
o Digital							/			/	
o Hard Copy											
o Magnetic Transportable										/	
o Other											
Format											
o Free											
o Semi-Formatted											
o Formatted											
SYSTEM COMPONENTS											
o Subsystem Elements											
Functions											
Allocation Information											
SYSTEM FUNCTIONS											
o Input							/			/	
o Processing							/			/	
o Output							/			/	
SYSTEM INPUTS											
o Functions Requiring External Data											
o Characteristics of External Data											
Timeliness											
Accuracy											
Format											
Reliability											
Volume											

Key

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- [ ] = No information
- [/] = Reference, but no substance
- [X] = Useful but incomplete data
- [■] = Complete information

INFORMATION TYPE	SYSTEM																			
	TAC JAM	TCCF	TCC-39	TCS/TCT	TNS-10	TPQ-36	TPG-37	TSQ-73	TUFMIS	TYC-13	TRAILBLAZER	U/E ECM								
Frequency																				
SYSTEM OUTPUTS																				
o Type of Information																				
o Users of Information																				
o Required Characteristics of Information																				
INFORMATION TRANSFER MEDIA CONTINUITY																				
OF OPERATIONS																				
o Mission																				
o Degraded Mode Processing Priority																				
o I/O Redundancy																				
o Alternative Data Access Methods																				
HUMAN FACTORS																				
o Error Minimization																				
o Self Test Capabilities																				
o Modular Parts Replacement																				
o Component Mobility																				
o File Protection (from users)																				
o Control Characteristics																				
o Operator Prompting																				
SECURITY																				
o Clearances Required																				
o Identification of Users & Terminals																				
o Identifier Codes																				
o Access Rights to Data Base																				
o Classification of Data Elements																				
STANDARDIZATION																				
o Data Element Dictionary (DED)																				
o JINTACCS Conformance																				
o Message Formats																				
o Deviations from Standards																				

Key

- • = N/A
- (blank) = No information
- / = Reference, but no substance
- X = Useful but incomplete data
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INFORMATION TYPE	TACJAM	TCCF	TCC-39	TCAS	TCS/TCT	TNS-10	TPQ-36	TPQ-37	TSQ-73	TUFMIS	TYC-13	TRAILBLAZER	U/E ECM						
THREAT																			
o Speed of Threat Evolution												X							
o Class of Threat									■			■							
o Probable Operating Context									/			X							
COMMANDERS MISSION AND FUNCTION																			
o Information Required												X							
o Timeliness Required												X							
PRECURSOR SYSTEMS																			
o Type																			
o Employment																			
o Sources of Data																			
SHORTFALLS ADDRESSED																			
o Type of Shortfall									■			■							
o Impact of Shortfall																			
o Priority Ranking									■			■							
TERRAIN AND CLIMATE																			
TRAINING																			
o Type																			
o Amount									X										
PERSONNEL																			
o Quantitative									X			X							
o Qualitative									/			X							

APPENDIX B

TYPES OF UNCLASSIFIED INFORMATION
OBTAINED FROM ABIC 79 DESCRIPTIONS
OF BATTLEFIELD AUTOMATED SYSTEMS

SYSTEM ACRONYM OR ABBRE-VIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	INFORMATION TYPE: MESSAGE	INFORMATION TYPE: WEAPON	INFORMATION TYPE: SENSOR	OPERATOR TYPE(S): CLERK	OPERATOR TYPE(S): OBS./COL	OPERATOR TYPE(S): PROC. OPER.	OPERATOR TYPE(S): DATA BASE	OPERATOR TYPE(S): ANALYST	OPERATOR RANK(S): E2-E4	OPERATOR RANK(S): E5-E6	OPERATOR RANK(S): E7-E8, WO	OPERATOR RANK(S): O1-O3	OPERATOR RANK(S): O4-O5	COMBAT STRESS: CORPS REAR	COMBAT STRESS: DIV. REAR	COMBAT STRESS: STATIONARY VEH	COMBAT STRESS: MOVING VEH	COMBAT STRESS: FEBA	CRISIS MODE OPERATIONS: NO CHANGE	CRISIS MODE OPERATIONS: VERY SIMILAR	CRISIS MODE OPERATIONS: DIF. PRIORITIES	CRISIS MODE OPERATIONS: MOST DIFFER.	CRISIS MODE OPERATIONS: ALL DIFFER.
MEDMIS	Medical Management Information System	Academy of Health Sciences	1985	●			O			O		O		O			●	●				O				
MEDPAR	Medical Patient Accounting and Reporting System	Academy of Health Sciences	1985	●			O			O		O		O			●	●				O				
MEDLOG	Medical Logistics System	Academy of Health Sciences	1985	●			O			O		O		O			●					O				
MEDBLOOD	Whole Blood Management	Academy of Health Sciences	1985	●			O			O		O		O			●					O				
MEDREG	Medical Regulating System	Academy of Health Sciences	1985	●			O			O		O		O			●					O				
SIDPERS	Standard Installation/Division Personnel System	MILPERCEN	1972	●			O		O	O		O	O	O	O		●	●				O				
DAS3	Decentralized Automated Service Support System	LOGCEN	1980	●			O		O	O			O						O					O		
DS4	Direct Support Unit Standard Supply System	LOGCEN	1979,1980	●			O		O	O			O				●	●	●					O		
SAMS	Standard Army Maintenance System	LOGCEN	1982	●			O			O		O	O				●	●	●			O				
SAAS-1	Standard Army Ammunition System, Level 1	LOGCEN	1973	●			O		O	O		O	O	O	O		●							O		
SAAS-3	Standard Army Ammunition System, Level 3	LOGCEN	1981	●			O		O				O	O			●	●	●					O		
SAAS-4	Standard Army Ammunition System, Level 4	LOGCEN	1981	●			O		O			O	O				●	●	●					O		
DSU/GSU MLS	DSU/GSU Magnetic Ledger System	LOGCEN	1965	●			O					O							●					O		
CS3	Combat Service Support System	USACSC	1975	●			O		O	O		O	O	O	O			●						O		

SYSTEM ACRONYM OR ABBRE-VIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	INFOR-MATION TYPE			OPERATOR TYPE(S)					OPERATOR RANK(S)					COMBAT STRESS					CRISIS MODE OPERATIONS				
				MESSAGE	WEAPON	SENSOR	CLERK	OBS./COL	PROC. OPER.	DATA BASE	ANALYST	E2-E4	E5-E6	E7-E8, WO	01-03	04-05	CORPS REAR	DIV. REAR	STATIONARY VEH	MOVING VEH	FEBA	NO CHANGE	VERY SIMILAR	DIF. PRIORITIES	MOST DIFFER.	ALL DIFFER.
CIUS	Corps Intermediate Upgrade System and IBM 360/40	USACSC	1975-1979	●			O	O	O	O		O	O	O	O		●							O		
DLOGS	Division Logistical System	LOGCEN	1971	●			O	O	O	O		O	O	O	O			●	●					O		
MRM	Maintenance Reporting and Management System	LOGCEN	1971	●			O		O			O	O	O	O		●	●					O			
SAILS	Standard Army Intermediate Level Supply System	LOGCEN	1973	●			O		O	O		O	O	O			●		O				O			
ASAS	All Source Analysis System	USAICS	1986	●				O	O	O	●		O	O	O		●	●						O		
AGTELIS	Automatic Ground Transportable Emitter Location - Identification System (AN/TSQ-109)	USAICS	1983			●			O				O					●	O			O				
SOTAS	Standoff Target Acquisition System	USAICS	1984			●			O				O					●	O	O	O	O				
MAGIIC	Mobile Army Ground Imagery Interpretation Center (AN/TYQ-11(v)4)	USAICS	1981	●			O		O		O		O	O	O		●					●		O		
QUICKLOOK II	AN/ALQ-133	USAICS	1979			●			O				O	O	O		●					O				
TRAILBLAZER	AN/TSQ-114	USAICS	1982			●			O				O					●						O		
GUARDRAIL V	GUARDRAIL V	USAICS	1979			●			O				O				●							O		
SLAR/OV-1	Side Looking Airborne Radar Onboard OV-1 Mohawk Aircraft	USAICS	1980			●			O						O	O	●							O		
I-TEP	Interim Tactical ELINT Processor	USAICS	1979			●	-	-	-	-	-	-	-	-	-	-	●					O				
QUICK FIX	AN/ALQ-151	USAICS	1982		●	●			O					O				●	O					O		

SYSTEM ACRONYM OR ABBRE-VIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	INFOR-MATION TYPE			OPERATOR TYPE(S)					OPERATOR RANK(S)					COMBAT STRESS					CRISIS MODE OPERATIONS				
				MESSAGE	WEAPON	SENSOR	CLERK	OBS./COL	PROC. OPER.	DATA BASE	ANALYST	E2-E4	E5-E6	E7-E8, WO	O1-O3	O4-O5	CORPS REAR	DIV. REAR	STATIONARY VEH	MOVING VEH	FEBA	NO CHANGE	VERY SIMILAR	DIF. PRIORITIES	MOST DIFFER.	ALL DIFFER.
TACJAM	Tactical Jammer (AN/MLQ-34)	USAICS	1982		●	O			O				O	O			●	●	●							O
CAS ECM	Close Air Support Electronic Counter-Measures (AN/MLQ-33)	USAADS	1984		●				O				O	O				O								O
FAMAS	Field Artillery Meteorological Acquisition System (AN/TMQ-31)	USAFAS	1984	O		●			O				O					●	●		O	O				
GSRS	General Support Rocket System	USAFAS	1982		●				O				O													O
	Mortar Locating Radar, AN/TPQ-36)	USAFAS	1981			●			O				O					●	●	O	O	O				
	Artillery Locating Radar (AN/TPQ-37)	USAFAS	1980			●			O				O					●	O			O				
PADS	Position and Azimuth Determining System	USAFAS	1981			●			O				O						O	O		O				
RPV TADARS	Remotely Piloted Vehicle, Target Acquisition/ Designation Aerial Reconnaissance System	USAFAS	1984			●			O				O						●					O		
BCS	Battery Computer System	USAFAS	1981	●		●		O	O	O		O	O		O				●	O	O			O		
TACFIRE	Tactical Fire Direction System	USAFAS	1979	●				●		O	O	O	O	O	O		●	●	●	●	●			O		
	Meteorological Data Processing Group (OL-192/GMD-1)	USAFAS	1979	●					O				O						O	O		O				
SHORAD-C2	Short-Range Air Defense Command and Control System	USAADS	1983	●	●	●			O	O	O		O	O	O			●	O					O		
ADEWS	Air Defense Electronic Warfare System	USAADS	1985-1987		●	●			O				O	O				●	O							O
	Missile Minder (AN/TSQ-73	USAADS	1979	●	●				O		O		O	O	O		●	●	●							O

SYSTEM ACRONYM OR ABBREVIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	INFORMATION TYPE			OPERATOR TYPE(S)					OPERATOR RANK(S)					COMBAT STRESS					CRISIS MODE OPERATIONS				
				MESSAGE	WEAPON	SENSOR	CLERK	OBS./COL	PROC. OPER.	DATA BASE	ANALYST	E2-E4	E5-E6	E7-E8, WO	O1-O3	O4-O5	CORPS REAR	DIV. REAR	STATIONARY VEH	MOVING VEH	FEBA	NO CHANGE	VERY SIMILAR	DIF. PRIORITIES	MOST DIFFER.	ALL DIFFER.
ICC/IPCP	Information Coordination Central (AN/HSQ-110) Improved Platoon Command Post (AN/MSW-13)	USAADS	1973	●	●				O				O	O			●	●				O				
Patriot CCS	Patriot Command and Control Set	USAADS	1982	O		O			O				O	O			●	●				O				
ECS	Engagement Control System	USAADS	1982		O				O				O	O			●					O				
DST	Nike Hercules Director Station Trailer (AN/MSQ-100)	USAADS	Fielded		●				O				O	O			●					O				
DAR	Defense Acquisition Radar	USAADS	TBD			●			O				O	O			●	●	O	O		O				
DLDED	Division Level Data Entry Device	SIGCEN	1982	●			●		O	O			O	O				O	O	O				O		
PLRS	Position Location Reporting System	CACDA	1984			●	–	–	–	–	–	–	–	–	–	–		●	●	●	●	O				
GPS	NAVSTAR Global Positioning System	SIGCEN	1986			●	–	–	–	–	–	–	–	–	–	–	●	●	●	●	●	O				
C^2 Exec.	Command and Control Executive Automated	CACDA	1986	●			O	O	O	O	O	O	O	O	O	O	●	●	●	O	O			O		
NBDS	Nuclear Burst Detection System	CACDA	1986			●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ATHS	Airborne Target Hand-Off System	USAAVNCEN	1984	●		●	–	–	–	–	–	–	–	–	–	–				●	–	–	–	–	–	–
ASSIST	Army Systems for STandard Intelligence Terminals	ACSI	1976	●						O	O			O	O	O	●							O		
IISS	Intelligence Information Subsystem	USAREUR	1979-1981	●						O	O			O	O	O	●							O		
ACS	Asset Control System	DCSLOG	1974	●			O	O	O	O		O	O	O	O		●					O				

SYSTEM ACRONYM OR ABBRE-VIATION	FULL NAME OR DESIGNATION OF SYSTEM	PROPONENT	IOC DATE	INFORMATION TYPE: MESSAGE	WEAPON	SENSOR	OPERATOR TYPE(S): CLERK	OBS./COL	PROC. OPER.	DATA BASE	ANALYST	OPERATOR RANK(S): E2-E4	E3-E6	E7-EB, WO	01-03	04-05	COMBAT STRESS: CORPS REAR	OIV. REAR	STATIONARY VEH	MOVING VEH	FEBA	CRISIS MODE OPERATIONS: NO CHANGE	VERY SIMILAR	DIF. PRIORITIES	MOST DIFFER.	ALL OIFFER.
DAMMS	DA Movements Management System	LOGCEN	1978	●			O	O	O			O	O	O			●			O				O		
DASPS	DA Standard Port System	LOGCEN	1974	●			O	O	O			O	O	O										O		
VFDMIS	Vertical Force Development Management Information System	DCSOPS	1981	●			O	O	O			O	O	O	O		●							O		
VTAADS	Vertical, The Army Authorized Document System	DCSOPS	1973	●			O	O	O			O	O	O	O									O		
TAPER	Theater Army Personnel Roll-up System	USAREUR	1978-1979	●			O	O	O	O		O	O	O	O									O		
MPMIS/PWIS	Military Police Management Information System/Prisoners of War Info. System	USAMPS	Operational	●			O	O	O	O		O	O	O	O		●	●						O		
TASC	Theater ADP Service Center	ADMINCEN	1982	●			O	O	O	O	O	O	O	O	O		O							O		

APPENDIX C

SAMPLES OF BRIEF REPORTS PREPARED DURING SURVEY OF ARMY BATTLEFIELD AUTOMATED SYSTEMS

DLDED--Division Level Data Entry Device

DLDED--THE DIVISION LEVEL DATA ENTRY DEVICE

PURPOSE AND MAJOR FUNCTIONS

At present, personnel administration and logistics input to the Army division's Combat Service Support System (CS3) depends on punched cards. The Division Level Data Entry Device (DLDED)[1] will replace the punched card method with an ADP data entry system, to reduce both error rates and turn-around time. Intended as the standard data entry system for supply, maintenance, and personnel administration operations of the division, the DLDED will support the following user functions:[2]

a. Data entry.

b. File processing.

c. Data communication.

d. Report generation.

e. Inquiry/retrieval from files.

f. Text editing.

g. Arithmetic calculation.

h. Data display and manipulation.

i. Prompting.

These functions encompass virtually all user/operator transactions with admin/log ADP systems, all of which employ punched card, batch-processing methods. Therefore, the following description constitutes a preliminary human factors analysis for all those systems, since the DLDED will provide user/operator input for every one of them.

1/ *DLDED--Division Level Data Entry Device. Functional System Requirement.* U.S. Army Administration Center, Systems Design Directorate, Fort Benjamin Harrison, Indiana, undated.

2/ *Letter of Inquiry (LOI) for the Division Level Data Entry Device.* Project Management Office, Tactical Management Information Systems, Fort Belvoir, Virginia, 15 Dec 1979.

RELEVANT HARDWARE ELEMENTS

The DLDED will be a subsystem of the division CS3, in practice. A typical infantry division will have 54 systems, allocated as follows:

a. 17 combat battalions, 1 each.

b. 17 combat support, combat service support, and headquarters units, 1 each.

c. Personnel Service Division of the Military Personnel Office (MILPO) at the division's AG Company, 8 each.

d. Division Finance Company, 12 each.

Specific hardware elements have not yet been selected, according to documents currently in Synectics' possession as of 12 May 1980. Nonetheless, the Letter of Inquiry cited above specifies that the DLDED will be configured from off-the-shelf equipment, to include the following major components:

a. Computer, including CPU, memory, clock, controller's control panel, and bus.

b. Direct Access Storage (DAS).

c. Keyboard Visual Display Unit (KVDU).

d. Hard-copy printer.

e. Magnetic storage device with portable magnetic medium.

f. Communications capability.

g. Power subsystem.

h. Capability to add:

   1. Up to 3 KVDU per DLDED.

   2. 9-track magnetic tape unit (for CS3 interface).

   3. A Deutches Bundespost-approved modem.

The Keyboard Visual Display Unit (KVDU) is the device of greatest concern to this contract. The Letter of Inquiry specifies that the display screen shall display a minimum of 24 lines, with a minimum of 80 characters per line. The display character set shall consist of the 64-character ASCII

subset at a minimum, with zero distinguishable from alphabetic "O" and displayed characters identical to their keyboard counterparts. In addition, the KVDU must have the following characteristics:

a. Internal storage for one complete screen of characters.

b. A programmable cursor.

c. Format control by field, to include tab and field protect.

d. Character and line delete features.

e. Line and page erase of unprotected characters, to be replaced with blanks.

f. User/operator response to computer-generated request for cursor position.

g. Program selectable transmission of protected or unprotected data fields.

h. Attention devices such as blinking, under software control.

i. The keyboard must contain at a minimum the standard 44-key QWERTY format plus a separate 10-key calculator keypad.

j. Control keys for the cursor, to include right, left, up, down, home (move cursor to upper left corner), and clear screen (homing cursor after screen is cleared).

k. Keys for line feed, carriage return, print, and transmit.

l. Wraparound (last character of a line to first character of the next line down, and from first character of a line to last character of the next line up).

m. At least 10 function keys separate from the alphanumeric keys.

USER/OPERATOR CONFIGURATIONS

User/operator configurations are extremely simple in the DLDED. As noted previously, 54 systems will be installed in the typical infantry division, functioning as subsystems in the division's CS^3. However, available documentation suggests that these will not interact with each other. As described in the functional system requirement document (Note 1 above), data originate at the company level and are sent to battalion as hard-copy.

DLDED users/operators at battalion will transcribe the data at the KVDU. The input device will be an intelligent terminal. At battalion, it will provide extensive tutorials and prompts, plus limited editing capabilities, so that users/operators will not require lengthy training either in admin/log functions or in operating the terminal. The system will format these data into files and then write the files onto a 9-track output tape. The tape from each battalion will be delivered to division-level units (DMMC for logistics-AG company for personnel). At the division-level, the tapes will be processed by clerks who are trained in the personnel administration or logistics functions; the DLDED therefore will have fewer tutorial and prompting capabilities and greater editing capabilities to permit manipulation of the data. The division-level admin/log clerks will merge tapes from lower units, generating an output tape for each major function in CS3 (personnel, supply, and maintenance.) These tapes will be delivered to the Division Data Center (DDC), where they will become inputs to CS3. The data flow described here is summarized in Figure 9, which portrays only the data flow for the Standard Installation/Division Personnel System (SIDPERS), but is typical of logistics data flows as well.

At least two DLDEDs will be used as data flows up from the company to CS3, one at battalion and one at division. However, there appears to be no interaction between the two; one provides input to the other in a kind of sequential batch-processing mode. Therefore, the best characterization of user/operator configurations in the DLDED evidently is that of a single user/operator, interacting with his or her own terminal.

DESIGN FEATURES

Because hardware elements have not yet been selected for the DLDED and software programming has not yet begun, little can be said about the system's design features. Even so, the available documentation suggests that there are aspects of the DLDED which afford greater than average facility or versatility for a system of this type. Some examples of these capabilities include:

a. The DLDED executive system allows for concurrent execution of and communication between two or more programs/tasks. It also provides techniques for executing programs/tasks that exceed available main memory.

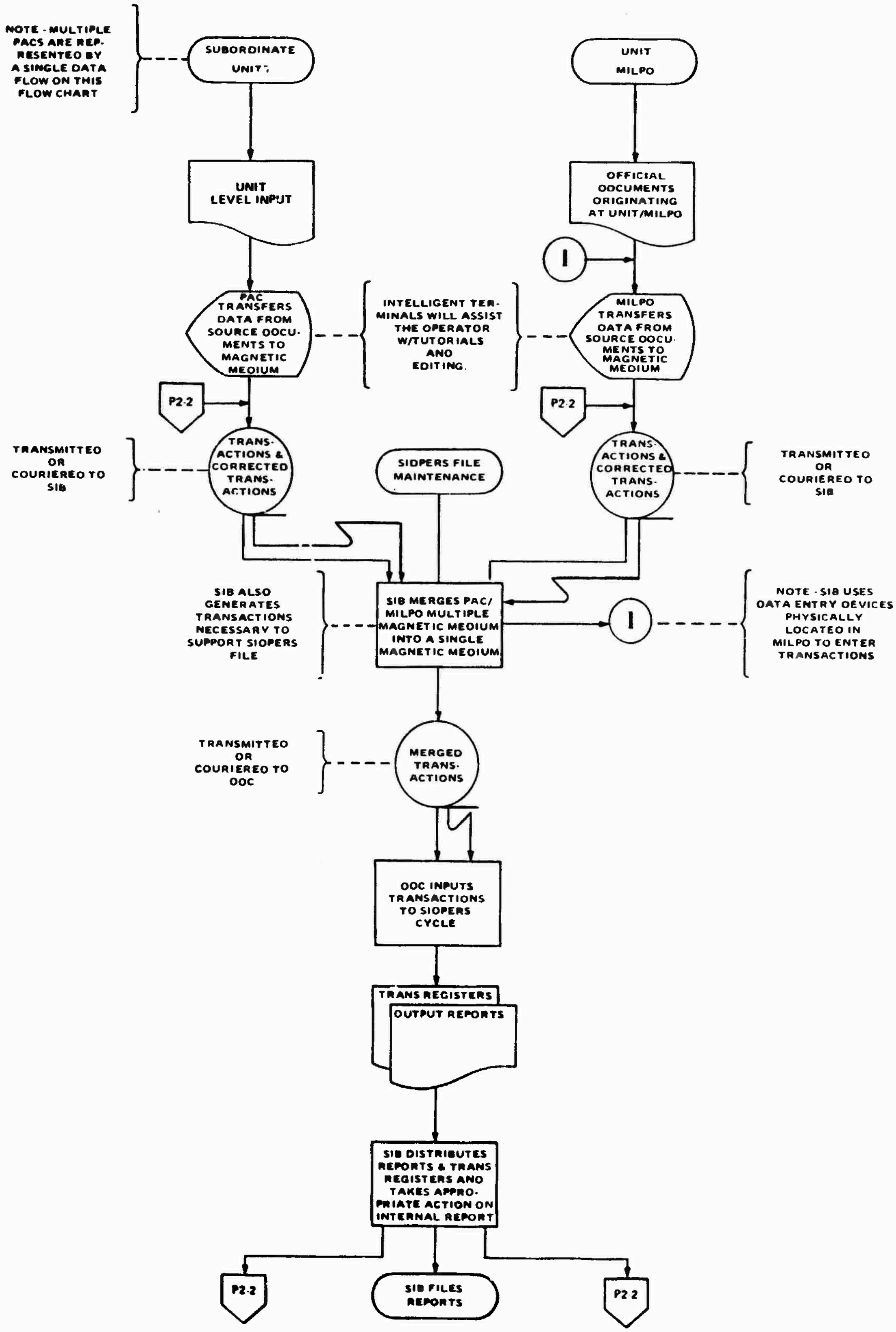

Figure 9. Data Flow for SIDPERS Supported by DLDED. (Reproduced from functional requirements document--see Note 1 in text.)

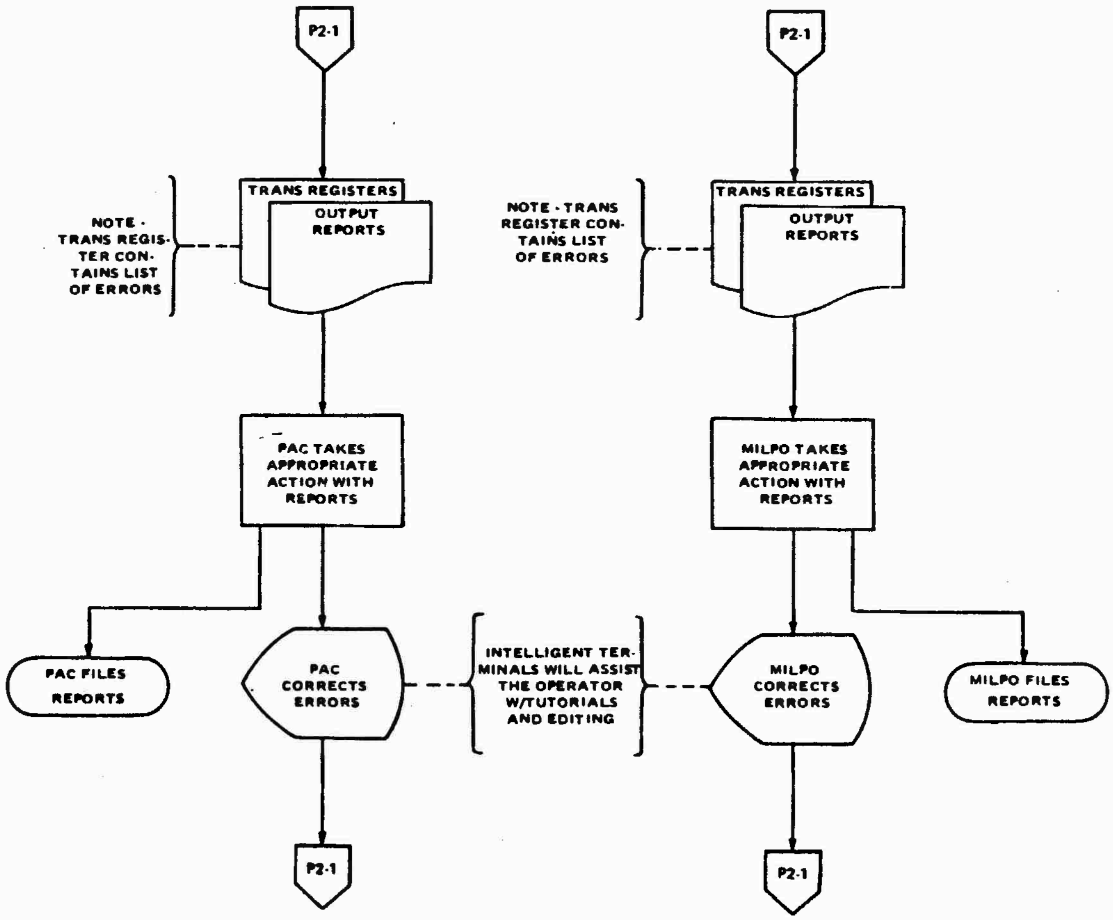

Figure 9. (Continued)

b. An on-line HELP facility provides information and guidance on the use of programs, system utilities, and user command and system message interpretation.

c. Edit and validation checks are established for a wide variety of formats and content.

d. Utility services are available through a program object library and executed from either the console or an applications program. These services include: routines for converting encoded data from one character set to another; a Core Dump for listing the content of main memory; a Panic Dump for listing the contents of selected areas of main memory; media to media routines; a Patch facility for entering interim modifications to operational and applications software; a facility for creating and using *ad hoc*, one-time report formats; and a facile soft/merge records capability.

IISS--Intelligence Information
System: First Milestone System (FMS)

IISS--INTELLIGENCE INFORMATION SUBSYSTEM
FIRST MILESTONE SYSTEM (FMS)

PURPOSE AND MAJOR FUNCTIONS

"The IISS FMS[1] is an all-source, mobile, tactical intelligence data handling system."[2] In part derived from the Army System for Standard Intelligence Terminals (ASSIST), the FMS is an independent subsystem of the U.S. Army Europe (USAREUR) Command and Control Information System (CCIS). It extends the information processing and intelligence disseminating capabilities currently provided by the U.S. European Command's Analyst's Information Display and Exploitation System (EUCOM AIDES) and by ASSIST. Indeed, TRW provides a software package that upgrades ASSIST to roughly the same capabilities as the FMS.

The major purpose of the FMS is to assist intelligence analyst users to provide accurate and timely tactical intelligence to commanders in Army Corps and subordinate echelons of USAREUR, down to the division or separate brigade level. Its primary functions[3] are:

1. On-line ADP support to intelligence analysts.
2. Access to multiple intelligence data bases through remote terminals and interconnected facilities.
3. Machine-aided sanitization of intelligence for release to collateral systems.
4. Acceptance of products from tactical collection systems.
5. Processing of ELINT data.

1/ Also referred to in some quarters as "I^2S^2", and in the TRW documentation more simply as "FMS".

2/ Hardware Operations Manual for Intelligence Information Subsystem (IISS) First Milestone System (FMS). TRW Defense and Space Systems Group, Document No. 28503-W104-RU-00, 6 June 1979, page 1.

3/ These functions are derived from the FMS Hardware Operations Manual (see Note 2 above) and from IISS Users Manual. TRW Defense and Space Systems Group, Document No. 28503-W094-RU-00, 10 May 1979.

6. Processing of data base files on records extracted from the EUCOM AIDES Integrated Data Base (IDB) and the USAREUR Integrated Ground Order-of-Battle System (IGOBS) data base.

7. Dissemination of user-to-user message traffic in FMS and upgraded ASSIST.

8. Access to:

    a. FMS Tactical Order-of-Battle (TACOB) data base.

    b. FMS Training data base.

    c. ASSIST Locally Developed Files data base.

    d. EUCOM AIDES IDB (through time sharing and remote job entry).

RELEVANT HARDWARE ELEMENTS

IISS's hardware elements are contained in three truck-mounted complexes: a Mobile Intelligence Center (MIC) and two Mobile Remote Intelligence Terminals (MRITs).

Mobile Intelligence Center

The MIC provides the primary FMS data base and a master control terminal for the system. Through the Intelligence Data Handling System Communciations II (IDHSC-II) network, AUTODIN, and local facilities, the MIC also serves as the primary communication center for the FMS, linking the MIC and MRITs to each other and to:

1. Tactical collection system inputs.

2. EUCOM AIDES.

3. National files and the DoD Intelligence Information System (DODIIS).

Each MIC contains, among other equipment, an AN/GYQ-12(V) computer with a 1.128-Mbyte memory, five 67-Mbyte disk drives, three nine-track tape drives, a high speed impact line printer, one analyst terminal, one computer terminal, an AUTODIN interface terminal, and high security communications equipment. The MIC, as shown in Figure 1, is housed in three truck-mounted, radio frequency interference (RFI) shielded shelters.

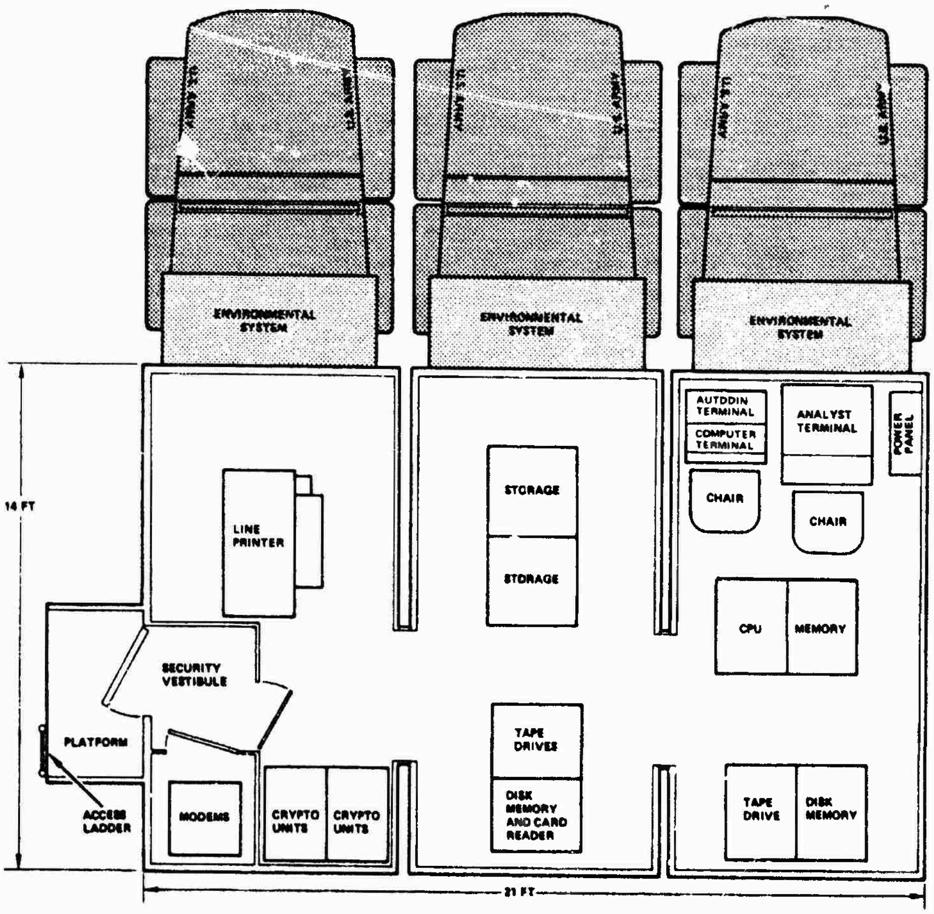

Figure 1. The FMS Mobile Intelligence Center (MIC) Reproduced from <u>*IISS Intelligence Information Subsystem for USAREUR*</u>. TRW pamphlet, 1978.

Mobile Remote Intelligence Terminal

The MRIT provides work stations for either three or seven intelligence analyst users, depending on configuration. Figure 2 shows a seven-position, large MRIT (MRIT-L); a three-position, small MRIT (MRIT-S) consists of the two outer shelters shown in the figure. Both the large and small MRIT provide a local data base, and when deployed can also contain the TACOB data base. Each also serves as a secondary communications center for tactical collection system inputs via AUTODIN, and for the MRITs' communciations with the MIC, other MRITs, and remote user terminals.

The MRIT equipment includes an AN/GYQ-12(V) with a 640-Kbyte memory, three 67-Mbyte disk drives, one nine-track tape drive, a high-speed, electrostatic line printer, three or seven analyst terminals, a CALCOMP 990 high-speed plotter, an AUTODIN interface terminal, and high security communications equipment.

Remote Terminals

In addition to equipment housed in the MIC and MRIT shelter complexes, the FMS also provides support to remote terminals. Currently, these terminals are located at V and VII Corps, and at PCAC, 66th MI, the U.S. Command in Berlin, and the USAREUR Systems Division.[4] Other remote terminals can be added as needed, because each MRIT is capable of supporting up to ten. Figure 3 shows the functional interrelationships of the system components.

SU 1652 Users Terminal

Of greatest importance to this contract is the hardware with which users/operators communicate with the system. The bulk of that communication takes place through OS-389(V)/G intelligent terminals in the Sperry Univac type SU 1652 configuration.

> The SU 1652 user terminal contains dual screen CRT displays, a light pen on the right side, an alphanumeric keyboard and two types of function keys: Fixed Function Keys (FFKs) and Variable Function Keys (VFKs). The FFKs are divided into three

4/ IISS User's Manual, Figure 2-1, page 2-6.

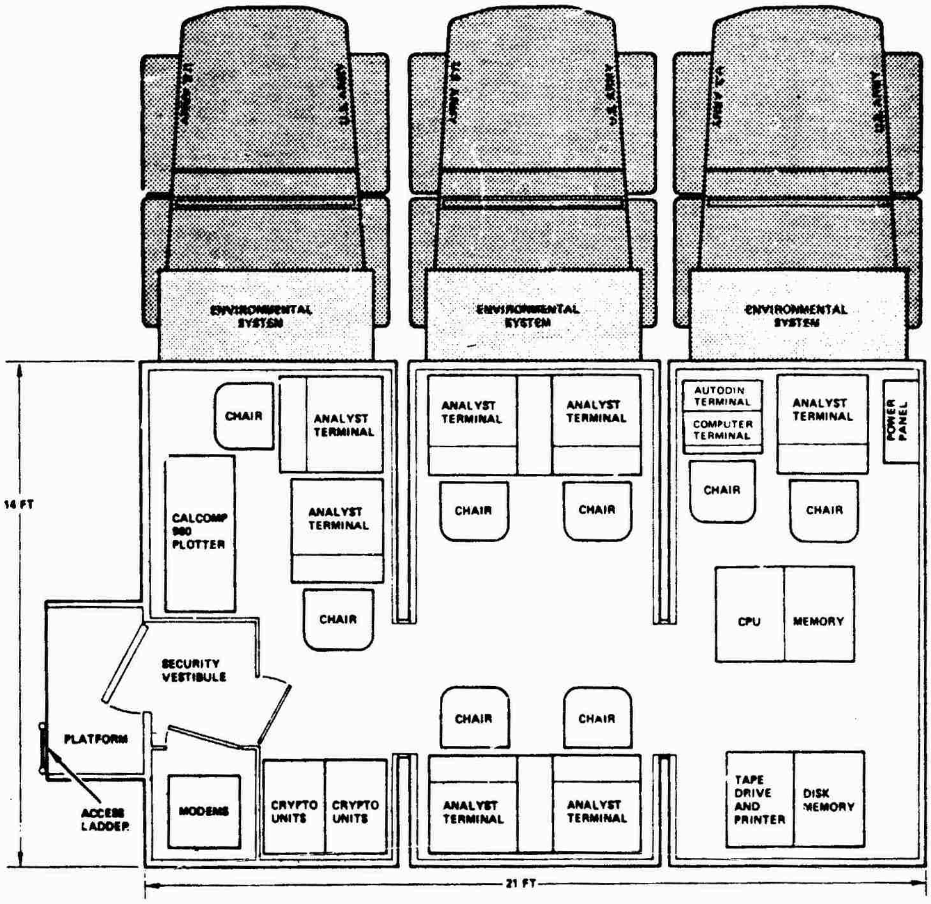

Figure 2. A three-shelter Mobile Remote Intelligence Terminal (MRIT-L). An MRIT-S is formed by using the two outer shelters above. Reproduced from *IISS Intelligence Information Subsystem for USAREUR*. TRW Pamphlet, 1978.

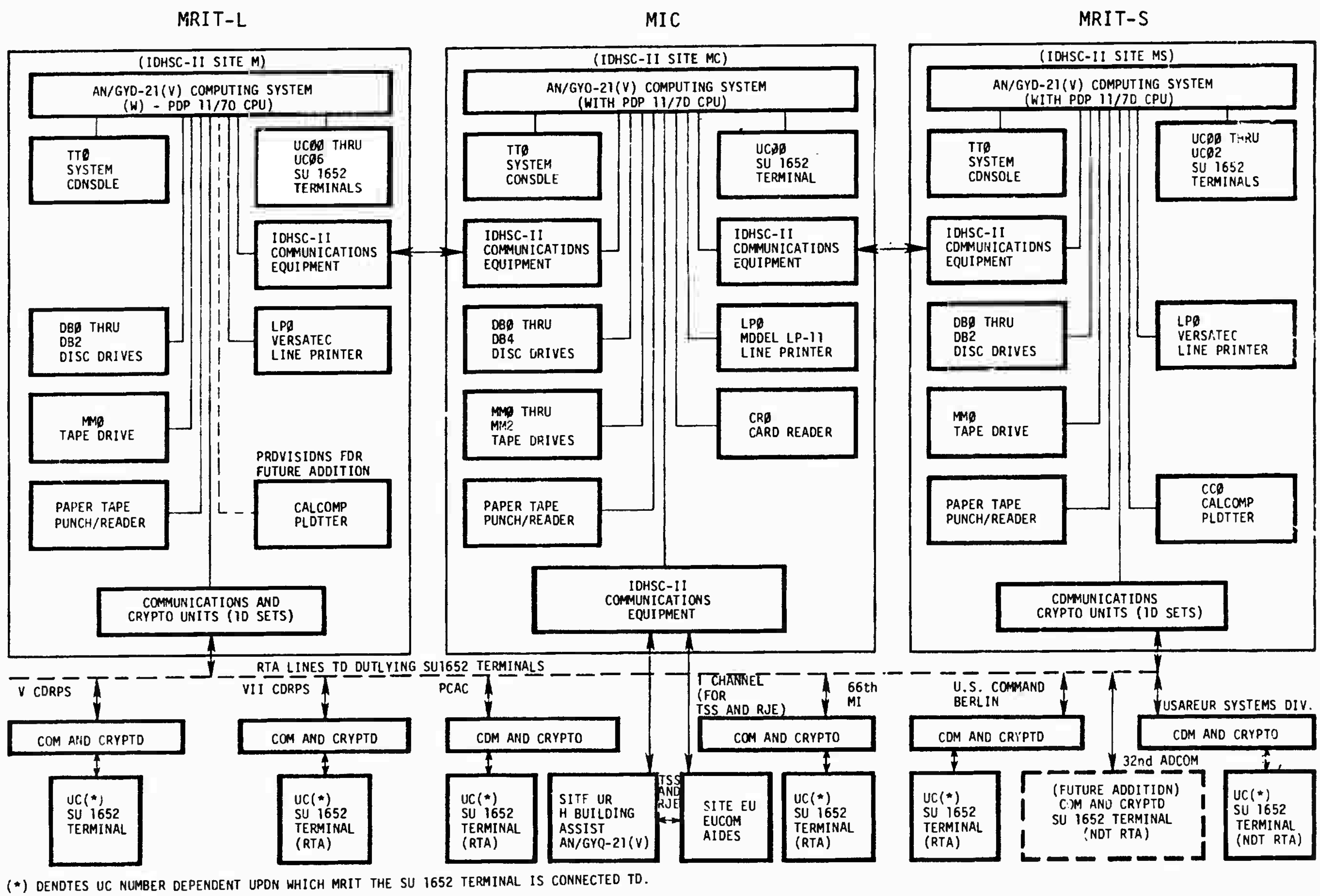

Figure 3. FMS Functional Interrelationships. Reproduced from *IISS User's Manual*.

groups, known as the upper, left and right FFKs, all positioned around the alphanumeric keyboard. The variable function keys (VFKs) are located on pads on each side of the left and right FFKs. The term variable in VFKs means the key can be either on or off, indicated by a panel light next to the key. Note that the left and right FFKs are different from the VFKs in that they have no on/off indicators and are always active.[5]

The two CRT displays are subdivided into screen areas (SA). These are:

SA-1 1 line on the top of the left screen for classification.

SA-2 19 lines in the middle of the left screen used as the major user area.

SA-3 4 lines on the bottom of the left screen used for messages.

SA-4 1 line on the top of the right screen for classification.

SA-5 19 lines in the middle of the right screen used as the major user area.

SA-6 4 lines for Command Line input and output, system status messages and error messages.

The FFKs located around the alphanumeric keyboard are used to perform editing and data positioning functions on the displayed data.

> The SU 1652 User terminal features contain editing capabiliites, such as character insertion and deletion, line changes, character string block manipulation and storage of limited data in the terminal. There is one left FFK, the "SEND FFK," that is very important to the user. The SEND FFK signals the external system computer to read the data in the SA containing the cursor and transmit that data to the system computer; this is how display data is transmitted to the system computer.[6]

5/ IISS Users Manual, page 2-23.

6/ *Ibid*, page 2-29.

> The Variable Function Keys (VFKs) provide the user a means of making entries controlling his interactive terminal environment and responding to FMS prompts. A VFK is active when the light indicator is on. Typically, the pattern of active keys on the left and right pads can change as a user proceeds through a menu option.[7]

There are several other pieces of hardware with which the user may interact at times. These include a line printer and a plotter. The other hardware such as the disk and tape drive, the computer, the crypto units and AUTODIN terminal are not used by the analyst user/operator. Therefore, only the interactions with the user terminal will be considered in this report.

USER/OPERATOR CONFIGURATIONS

Unlike many Army battlefield automated systems, the IISS FMS presently does not support complexes of users/operators performing widely varied functions at distinctively different terminals.[8] For example, TACFIRE supports Forward Observers, Fire Control Officers, and Artillery Intelligence Officers, to list only three users/operators. These individuals perform functions as varied as fire mission requests and artillery target intelligence assessment, using terminals as "dumb" as the DMD and as "smart" as the VFMED. By contrast, virtually every user/operator of the FMS is an intelligence analyst, performing intelligence functions at an SU 1652 terminal. While there is a capability for passing messages from one user to another, the great bulk of use involves the user/operator interacting with one or more intelligence data bases.

This is not to say that the scope of activities carried out within the intelligence function is simple or stereotyped. Indeed, these activities are so varied and complex that they cannot be characterized adequately in a preliminary analysis of the system. A single example of a series of user/

7/ *Ibid*, page 2-34.

8/ There is, however, no intrinsic reason why it could not do so, should the necessity arise.

operator transactions will suffice to illustrate this point. Consider a user/operator who wishes to perform a series of operations on the Ground Order-of-Battle section of the TACOB data base.

The first step is to LOGON to the user terminal (Figure 4). Next, the MASTER MENU is selected. Then the classification and a caveat are entered using the MARK operation. The user/operator then returns to the MASTER MENU and performs the GIM selection. A DATA BASE SIGNON to the TACOB data base is performed next. From the GIM MENU the specific files to be accessed are chosen. The file relationships for creation, index, retrieval, translation, and validation available to the user/operator at this point are illustrated in Figure 5. After all desired work has been done, the operator performs a SIGNOFF from GIM followed by a LOGOFF from the system.

DESIGN FEATURES

The IISS FMS provides a number of design features that are useful to the user/operator. For example, the Fixed Function Keys (FFK) and Variable Function Keys (VFK) permit the user/operator to enter a variety of commands with a single keystroke, rather than laboriously typing them in. Another example is the data management system's capability to accept a single command from the user/operator and then to update or retrieve data from every related file, rather than requiring him or her to repeat the command one or more times, specifying a different related file each time.

On the other hand, some of the FMS's design features could affect the user's/operator's transactions with the system. Examples of these design features are presented below.

a. Data Base Updates

Design feature: The FMS provides several different methods for updating the data codes within a file.

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[9] IISS FMS Software Operations Manual. TRW Defense and Space Systems Group, Document No. 28503-W093-RU-00.

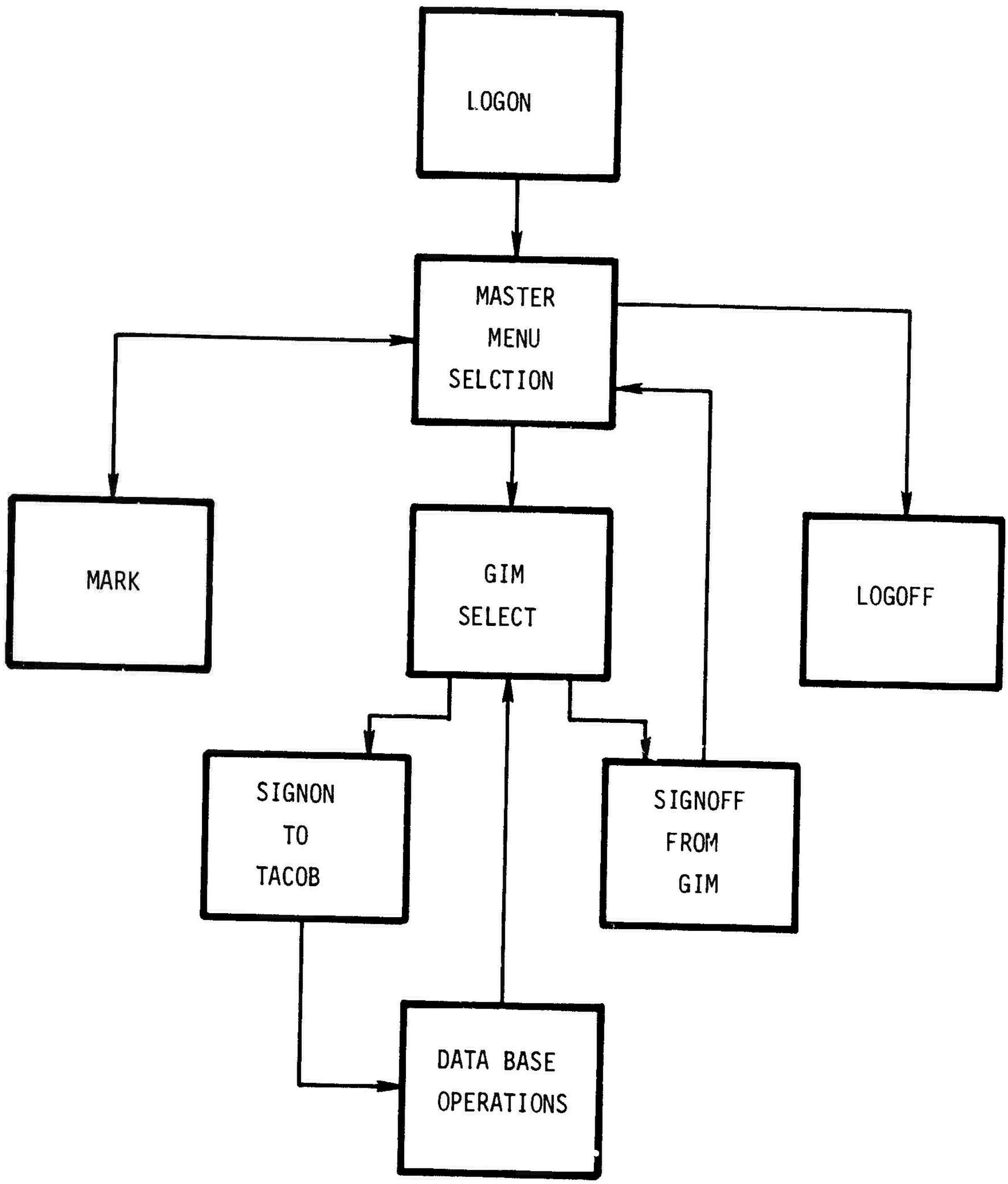

Figure 4. User/Operator Configuration For A Typical Series of IISS Transactions

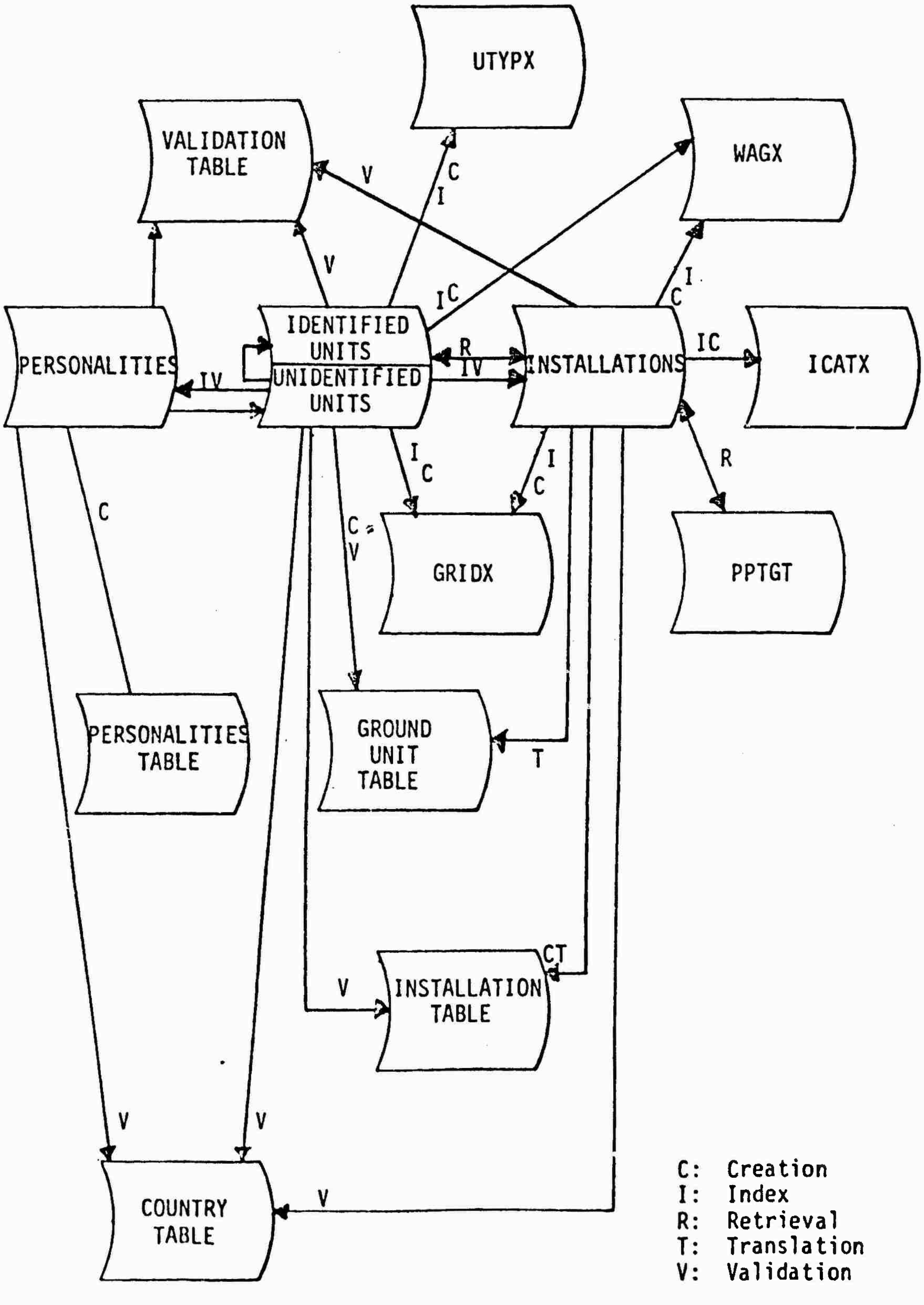

Figure 5. Ground Order-of-Battle File Relationships for Validation, update, Retrieval, and Translation (Reproduced from *IISS TACOB Data Base User Guide*. TRW Defense and Space Systems Group, Document No. 28503-W100-RV-00, 15 May 1979, Figure 3.2.1, page 16.)

Transactional implication: Generally only one specific updating method is associated with any particular given code; attempts to use other methods result in errors.

Predicted transactional problem: The FMS contains more than 100 data codes; associating the correct updating method with each code imposes a considerable memory load on the user/operator.

Detection/revocation of problem: The computer will detect attempts to use incorrect updating methods and will return an error message.

Consequences of the problem: The user/operator will require time to look up the correct method, or to derive it from error messages. In either case, updating time will be extended, thereby reducing the overall rate at which intelligence can be processed. The flow of intelligence to the commander could be reduced sufficiently to make more difficult his tactical decisions.

Recommended resolution: Develop a uniform user/operator procedure for updating data codes.

b. Updating Multivalued Fields

Design feature: Many of the fields in the TACOB data base files are multivalued fields. During updating functions, the user/operator has the capability to add new items to such fields, or to change or delete existing items. If the user does not specify particular items in a field, then executing a CHANGE or DELETE command will delete all items in the field.[9]

Transactional implication: In updating only a portion of a data record, the user/operator must exercise care to specify precisely the items to be changed or deleted.

Predicted transactional problem: Failure to specify precisely the data items to be changed or deleted will result in the entire multivalued field being deleted.

Detection/revocation of the problem: Complete data removal of an entire field is a legal operation with the TACOB data base. The system is therefore incapable of determining when such removal constitutes an error. Thus, unless the user/operator detects the error from console display feedback, such an error would go undetected.

9/ IISS FMS Software Operations Manual. TRW Defense and Space Systems Group, Document No. 28503-W093-RU-00.

Consequences of the problem: Data base integrity will be eroded. Reports may be prepared which lack significant or even vital information. Thus, the commander may be misled--perhaps seriously--in the picture he receives of the battlefield, particularly if disrupted communications prevent contradictory information reaching him from other sources.

Recommended resolution: Provide the capability for the system to prompt the user/operator to ensure that complete deletion of a multivalued field is intended wherever a CHANGE or DELETE command is entered without at least one item name. Alternatively, provide the capability for the user/operator to follow the CHANGE or DELETE command with ALL (or A), or perhaps FIELD (or F), when he or she actually wishes to delete all items in the field.

c. Plotter Output

Design feature: In preparing a plotter run, the Army Standard Intelligence Plotting System (ASIPS) listing provides the only source of feedback on the plot preparation run.

Transactional implication: The ASIPS listing was designed to be read by a technician trained on the ASIPS; few FMS users/operators have received that training.

Predicted transactional problem: Few FMS users/operators will be able to interpret the ASIPS listing properly.

Detection/revocation of problem: The system cannot detect many of the errors that could be made on the ASIPS run. Therefore, unless the user/operator detects an error while proofreading the ASIPS listing, that error will be propagated through the processing cycle and affect the final plot.

Consequences of the problem: At best, only the time required to redo the processing cycle would be lost. At worst, the plot would be missing information (or contain erroneous information) critical to the individual requesting the plot. This could result in bad decisions being made in critical battlefield situations.

Recommended resolution: Rewrite the ASIPS report generator to make it interpretable by the intelligence analyst user/operator on the FMS.

d. Sanitization Software

Design feature: Production of a sanitized intelligence report requires a sequence of procedures; one or more command statements controls each procedure, and intermediate output is produced by each. These outputs become inputs to the next procedure in the sequence.

Transactional implication: Detection of an error in any one (or more) of the sequential procedures requires a restart of the entire sanitization process.

Predicted transactional problem: Because the user/operator must reenter all sanitization commands, additional opportunities are provided to repeat errors or to commit new errors.

Detection/revocation of problem: An error may be detected by the user/operator before execution of the command, in which case the screen editor can be used to correct it. The machine may detect some errors, although the documentation[10] is not clear on this point. However, other errors not specified in the document can be detected only by carefully proofreading the sanitized report.

Consequences of the problem: An error detected in proofreading requires rerunning all of the report generating procedures, a time-consuming process which reduces the total useful output per unit of time. An undetected error might well result in a security violation and almost certainly would result in flowed data being delivered to report recipients.

Recommended resolution: Modify the sanitization software to provide the following capabilities: (1) save all of the commands that control each of the sequential procedures; (2) save the intermediate outputs of each procedure, keying then to the associated commands; (3) permit the user/operator to call up the saved commands for editing to correct errors; (4) permit the user/operator to start the recovery procedure at the point of the (first) error; (5) use the saved intermediate output of the procedure prior to the point at which recovery begins as input to the recovery procedure; (6) replace subsequent saved intermediate outputs with the outputs of the repeated procedures, in case another error must be corrected; and (7) provide an easy method to purge all saved outputs once an acceptable report is completed.

10/ IISS Sanitization Software Users Manual. TRW Defense and Space Systems Group, Document No. 28503-W095-RU-00, 12 March 1979.

e. Menu Selections

Design feature: When a user/operator wishes to select a function from a menu displayed on the terminal, he or she first uses the light pen to move the cursor to the desired menu item. The individual then presses the "SEND" FFK to transmit the selection to the processor.

Transactional implication: The user/operator must use two entry modes (keyboard and light pen) in coordination.

Predicted transactional problem: The procedure can be awkward, and is inconvenient, since the user/operator must either pick up the light pen, move the cursor, then put down the light pen and press the "SEND" FFK, or else use two hands for the procedure.

Detection/revocation of the problem: Not applicable in this situation.

Consequences of the problem: The principal consequence of this design feature probably is inconvenience to the user/operator. However, when the analyst's duties require extensive use of the system's menus, this nominal inconvenience could become a significant source of user dissatisfaction and frustration.

Recommended resolution: Number the items on each menu, and modify the software to permit the user/operator to type in the number of his or her selection.

ISIS--In Storage Information System

ISIS--THE IN STORAGE INFORMATION SYSTEM

PURPOSE AND MAJOR FUNCTIONS

ISIS is an interactive computer system which "...allows the user to interactively view, modify, and otherwise reorganize data bases that are of modest size, with hundreds rather than hundreds of thousands of data objects."[1] The system is not constrained with respect to application; users may define and utilize information relating to a wide variety of subjects. ISIS is not itself an Army battlefield automated system. Rather, it is a general purpose file- and information-handling system, and could be widely applicable in Army BASs. Indeed in the document cited above, it is illustrated in a tactical command and control application.

The basic functions of ISIS include:

a. File Definition: naming the file to be created.

b. Data Structure Definition: specifying the sequence and relationships of objects and attributes within the data file.

c. Data File Loading: directing the loading of a particular file from peripheral memory to main memory.

d. Information Display: directing specified information from the computer's memory to the user terminal.

e. File Element Restructuring: resequencing the information in a file on the basis of numerical, textual, or symbolic attributes.

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[1] Shukiar, H.J., Bush, C.H., and Gammill, R.C. *An Introduction to the ISIS Interactive Information System*. Report R-2435-AF, Rand Corporation, Santa Monica, CA; April 1979, p. v.

f. <u>Data File Content Editing</u>: adding to, deleting from, and altering the contents of ISIS data files.

g. <u>File Manipulation and Editing</u>: adding, deleting, and moving files.

h. <u>Display Formatting</u>: defining the position in which information is to be displayed at the user terminal.

i. <u>Hierarchical Data Structure Definition</u>: defining superior-subordinate or "parent'child" relationships among classes of data.

j. <u>Data Selection Criteria Specification</u>: identifying characteristics of data objects and attributes and the ways in which these characteristics are to be used to determine disposition of data.

RELEVANT HARDWARE/SOFTWARE ELEMENTS

Available ISIS documentation does not provide much information on the hardware elements of the system. ISIS was developed and implemented on a Digital Equipment Corporation PDP 11/70 minicomputer. An unspecified terminal was employed, and a hard copy output device may be available in some implementations. No further hardware specification is available.

ISIS runs under the UNIX operating system, and is written in C, "a general-purpose programming language...used as the primary programming language on the UNIX operating system..."[2] Since C compilers are not yet widespread, applications of ISIS in Army BASs may be limited. Currently C compilers are available for DEC PDP-11 series minicomputers, the Honeywell 6070, and IBM-370 series mainframes, the Interdata 8/32, and some microprocessors. The current paucity of C compilers does not, however, limit the

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2/ Aho, A.J. and Ullman, J.D. *Principles of Compiler Design*. Addison-Wesley, Reading, MA, 1977, p. 557.

generalizability of ISIS concepts, command language, and design features. There appears to be no aspect of ISIS which could not be easily implemented in any common general-purpose language.

USER/OPERATOR CONFIGURATIONS

Unlike many Army battlefield automated systems, ISIS presently does not support complexes of users/operators performing widely varied functions at distinctively different terminals.[3] Purposes of use may vary, of course, and several persons may use the system concurrently through its time-sharing capability. Nonetheless, the best characterization of the current user/operator configuration is that of a user who is also an operator, sitting at a terminal and interacting with a data base *via* ISIS facilities.

DESIGN FEATURES

ISIS contains a number of design features which make it an attractive system from the standpoint of human/computer interaction. These include:

a. English-like Command Language, which enables relatively naive users to quickly grasp the essential elements of the ISIS command structure.

b. Hierarchical Command Complexity, allowing the novice user to perform useful activities with a relatively simple and constrained command set while at the same time permitting the experienced user to exercise a detailed and powerful set of commands.

c. Use of "Throwaway" Terms, which make the command strings more English-like, but are ignored by the computer. The terms "the",

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3/ There is no intrinsic reason why it could not, however.

"an", and "a" are examples of "throwaway" terms, so that the command strings:

Load the frags from the fighter_frag file

and

Load frags from fighter_frag file

are functionally equivalent in ISIS.

d. Command File Capability, permitting the experienced user to "program" ISIS operations and to develop "macro commands." Both of these capabilities reduce the number of keystrokes required to perform a given ISIS operation. This capability is particularly useful when file contents are volatile but the operations performed on the files tend to be repeated periodically.

e. Display Formatting, permitting the user to organize information for display in the manner which best supports a given task.

f. Information Subsetting, which allows users to test information to determine whether or not it is useful for a particular purpose (display, save in a file, etc.).

Design Features Affecting User/Operator Transactions

Although the human/machine interface in ISIS is generally quite good, some design features could affect user/operator transactions with the machine components of the system. These design features are discussed below, in the context of ISIS as a component of an Army tactical command and control system.

a. Dictionaries

Design feature: ISIS provides no access to file dictionaries, stored format dictionaries, or perform file dictionaries.

Transactional implication: The user/operator cannot review lists of the data or display formats available to him or her.

Predicted transactional problem: Access to required information may be delayed because of difficulty in locating data files.

Detection/revocation of problem: The user/operator may be forced to resort to off-line documentation or other, more knowledgeable users/operators, neither of which may be immediately available under tactical conditions. Alternatively, the user/operator may have to hunt through files sequentially to locate the necessary information.

Consequences of problem: Information needed by the commander for tactical decision-making may be delayed. Information needed by the staff to support the commander's concept may be delayed. In some circumstances, command and support decisions may have to be made with less or lower-quality information than would otherwise be available. Depending on the situation and other information sources, impact on the success of the mission could be severe.

Recommended resolution: Create separate, on-line file, format, and perform file dictionaries which provide names and explanations for all data files, display formats, and program files. Design features of these dictionaries should include:

1. Automatic updating to reflect effects of most recent file transactions.
2. Alphabetical listings of file names, format names, and perform file names.
3. Redundant alphabetical listings by discrete elements of file, format, and perform file names.

4. Hierarchical listings by subject.

5. "Back trace" listings to indicate files, formats, and perform files by specific attributes.

b. Command Strings

Design feature: ISIS provides no command function keys or command menus. All commands are entered as character strings by typing on an alphanumeric keyboard. Some of these strings are quite long, running to several lines on the 80-character-per-line display. Each time the user/operator executes a carriage return, ISIS evaluates the just-entered line fcr syntax errors. If an error is detected, ISIS outputs the appropriate message immediately. The user/operator must then enter a period (the signal to ISIS that entry of a command is completed), execute a carriage return, and re-enter the entire command.

Transactional implication: Considerable time can be wasted in re-entering commands. User/operator may become frustrated if he or she is nearing the end of a command when an error occurs and is certain to become frustrated if more than one or two attempts are required to enter the command.

Predicted transactional problem: Access to required information may be delayed because of command entry errors. Hightened user/operator frustration will increase the probability of such errors, and may initiate a vicious cycle of error-frustration-error, etc., particularly in stresful tactical situations.

Detection/revocation of problem: Unless the terminal has a screen editor (which is not clear from the documentation), the user/operator is helpless in this situation. All errors, whether

self- or system-detected, force him or her to begin entering the command again from the start.

Consequences of the problem: Same as for the previous design feature.

Recommended resolution: At present, the user's/operator's only recourse appears to be to exit from ISIS, invoke the "Rand Editor"[4, 5] and to construct his or her command strings in what is called a "perform file" (a kind of macro). The user/operator then invokes ISIS again and executes the perform file. While this procedure is acceptable for "programming" command sequences that will be used repeatedly, it is awkward and time-consuming for on-line, interactive sessions intended to obtain immediate results. To resolve the problem, provide an editing capability in ISIS itself to permit the user/operator to edit a single character, a word, a phrase, or an entire line of command text. Also, modify ISIS to evaluate syntax and grammar character-by-character for syntax errors, and to allow the user to continue entering the command from the end of the line in which the error occurred.

c. Command Language Semantics

Design feature: ISIS commands must be entered in their entirety; the system does not provide any mnemonics or other "shorthand" features.

4/ Bilofsky, W. *The CRT Text Editor NED--Introduction and Reference Manual.* The Rand Corporation, R-2176-ARPA, December 1977.

5/ Kelly, J. *A Guide to NED: A New On-line Computer Editor.* The Rand Corporation, R-2000-ARPA, July 1977.

Transactional implication: Experienced users/operators value shortcuts to command entry and become impatient when they are not provided.

Predicted transactional problem: ISIS's lack of adaptation to user/operator experience with command syntax may lead from impatience to frustration, with an attendant increase in errors and delay in access to information.

Detection/revocation of problem: While the experienced user/operator can detect the problem readily, there is nothing he or she can do about it.

Consequences of the problem: In most situations, the most probable consequence is merely user/operator dissatisfaction with the system. In some tactical situations, however, the consequences could be the same as for the lack of file, format, and perform file dictionaries.

Recommended resolution: Provide mnemonics for system commands (e.g., AP for Append, DS for Display, IN for Insert, etc.).

d. Display Formats

Design feature: In some--though not all--ISIS columnar displays, only the left-most column is justified. Thus, for example, the template for the data set called "frags" would be displayed as follows:

```
        template for set frags (
   (unit, symbol        )
   (missn_no, integer   )
   (aircraft, symbol    )
   (num_ac, integer     )
```

```
(call_sign, symbol  )
(tot, time          )
(request_no, text   )
(missn_type, symbol )
(prim_target, symbol)
(sec_target, symbol )
(fac_sign, text     )
(ord_load, symbol   )
(iff_sif_comm, text )
(ecm, text          )
(remarks, text      )
(aar_time, time     )
(tanker_sign, text  )
(aar_alt, symbol    )
(aar_dur, time      )
)
```

Transactional implication: User/operator cannot rapidly scan right-hand columns (for example, to determine the type of data associated with a particular attribute name in the above display.) Also, he or she is prevented from easily using the lengths of the character strings in right-hand columns as a searching cue, which further reduces capability for rapid scanning.

Predicted transactional problem: User/operator efficiency is reduced, thereby increasing time to access required information.

Detection/revocation of the problem: The user/operator can readily detect the problem, but cannot do anything about it.

Consequences of the problem: Same as for Command Language Semantics feature.

Recommended resolution: Justify all columns of columnar displays. Left-justify columns of alpha strings and right-justify columns of numeric strings.

e. Numeric Calculations

Design feature: ISIS permits only integer numerical calculations, in the range $-32767 < x < +32767$.

Transactional implication: A numerical calculation may lead to underflow or overflow, with a consequent system "crash."

Predicted transactional problem: The user/operator cannot enter data consisting of large positive or negative numerical values. Also, the user/operator cannot demand mathematical operations that will result in large positive or negative numerical values.

Detection/revocation of the problem: Same as immediately above.

Consequences of the problem: A system crash, of course, will prevent any results from being obtained. In situations requiring entry of values in excess of ± 32767, or resulting in such values, computations will have to be performed by hand. The result of sucn a procedure will be delay in obtaining needed information. Thus, the system cannot meet the commander's requirement for breadth of data.

Recommended resolution: ISIS should use double-precision integer arithmetic, providing a range $-2.15 \times 10^9 < x < +2.15 \times 10^9$, thereby allowing the user/operator greater computational power. The use of floating point arithmetic would provide even more power.

f. Relational Expressions

Design feature: Relational expressions (e.g., less than, greater than, etc.) are encoded (e.g., <, >, etc.).

Transactional implication: Users/operators who are not sophisticated in mathematics or ADP operations may not understand the relational expression codes.

Predicted transactional problem: Unsophisticated users/operators must search off-line sources for translations of codes. They may also misuse the codes, as for example entering < when they intend >.

Detection/revocation of problem: The system could not detect a misuse of a relational code. Thus, unless the user/operator or an observer detected the error, it would go into the system and affect the output

Consequences of the problem: An undetected misuse of a relational expression could produce radically misleading output. For example, a user/operator might be instructed to identify areas of the battlefield where concentrations of enemy tanks were greater than, say 15. If he or she entered "<" rather than ">", the output would show areas where the enemy concentrations were less than 15 tanks. If communications were

disrupted, the output might not be contradicted by other information sources. Artillery fire, and perhaps maneuver units, might then be directed to areas where enemy strength was lightest, meanwhile ignoring those where enemy strength was greatest and therefore most dangerous.

Recommended resolution: Provide on-line capability for users/operators to obtain definitions of relational expression codes (e.g., $<$ = less than, $>$ = greater than, $a < x < b$ = the value of x is between the values of a and b, etc.) Also, provide the capability for novice users to enter the expanded syntax rather than the codes (touch typists might also prefer expanded syntax, regardless of experience level.)

MAGIS IAC--Marine Air/Ground
Intelligence System
Intelligence Analysis Center

MAGIS IAC--MARINE AIR/GROUND INTELLIGENCE SYSTEM INTELLIGENCE ANALYSIS CENTER

PURPOSE AND MAJOR FUNCTIONS

The MAGIS IAC "...is the first true, all source facility ever employed in tactical intelligence."[1] The IAC will "...provide an all source intelligence data base together with functional computer programs to assist the Assistant Chief of Staff (AC of S), G-2, in the collection, interpretation, evaluation of information, and dissemination of intelligence produced affecting the command's areas of operation/interest. The intelligence matters of the IAC will be relevant to the following areas:

a. Enemy Order of Battle.

b. Target Intelligence.

c. Intelligence Collection and Direction.

d. Intelligence Reports."[2]

Ultimately, the IAC will provide the baseline for development of the LHA Intelligence Center (LHA-IC) Upgrade. This system will be used during the embarkation, deployment, and landing portions of an assault by a Marine Landing Force. During this portion of the operation, the MAGIS IAC is not used; it becomes operational only after command elements move ashore.

RELEVANT HARDWARE ELEMENTS

The hardware elements of the IAC are contained in three portable shelters, transportable by medium truck: an automatic data processing/communications (ADP/COM) shelter and two analyst shelters.

1/*Standing Operating Procedures (SOP) for the Development Test--Phase II and the Operational Test--Phase II of the Intelligence Analysis Center (IAC) in a Marine Amphibious Force (MAF) Deployment*. DL-TP-01Q-02-03. Naval Surface Weapons Center, Dahlgren, Virginia, April 1979, page iii.

2/*Ibid*, page 1.

ADP/COM Shelter

The ADP/COM shelter houses the IAC's main computer, the AN/UYK-7, with 131K bytes of memory in two bays. Magnetic tape and disks provide peripheral storage, and a plotter and printer provide graphic and alphanumeric hard copy. Other equipment in the shelter provides communication with the two analyst shelters and with the outside world. One terminal is also located in the ADP/COM shelter for use by the computer operator and the Log-Journal Clerk.

Analyst Shelters

Each analyst shelter contains a peripheral computer, the AN/UYK-20, a line printer, communications equipment, and workspace for four intelligence analysts. Each analyst is provided a Query/Response Unit (QRU), consisting of a keyboard and CRT display.

Two versions of the QRU were used in the IAC version demonstrated to the COTR and project personnel during a visit to the Naval Surface Weapons Center. In the older version, the screen is arranged vertically, while in the newer version, the screen arrangement is horizontal. Both versions contain a standard, 44-key QWERTY keyboard, cursor control keys, and several groups of fixed function keys. Though the arrangements of the screens and the fixed function keys differ in some details, the two versions of the QRU are functionally identical. Also, whether arranged vertically or horizontally, the display screen may be used as a single large screen or as two smaller screens. Thus, the analyst has a relatively large working area when he or she is interacting with the data base, and can use the split screen feature, when composing reports, to call up information required to fill in report formats.

USER/OPEPATOR CONFIGURATIONS

The MAGIS IAC's major purpose is to satisfy the intelligence needs of the tactical commander. In fulfilling this purpose, it supports the activities of a number of his subordinates, working in the shelters.

ADP/COM Shelter

Three individuals work in the ADP/COM shelter (Figure 6): the Watch Officer, the Log/Journal Clerk, and the ADP/COM Operator.

a. Watch Officer--The Watch Officer is in charge of the IAC, and exercises overall supervision of the IAC personnel and activities. He or she also has responsibility for monitoring incoming message traffic. Though incoming digital intelligence messages are routed to the appropriate analysts automatically by the computer, the Watch Officer reviews these messages and directs any additional routing he or she considers necessary. He or she also reviews all incoming hard copy and voice messages for priority and relevance, and directs their entry into the system and their routing to appropriate analysts.

b. Log/Journal Clerk--The clerk is responsible for the Intelligence Journal, in which is maintained a record of all messages and events pertinent to the intelligence section. He or she also operates the ADP/COM shelter's QRU, under the direct supervision of the Watch Officer, to enter hard copy and voice messages into the system and to perform necessary message routing procedures. In this respect, the clerk is the interface between the Watch Officer and the IAC system.

c. ADP/COM Operator--The operator has no intelligence analysis responsibilities. Under direct supervision of the Watch Operator, he or she operates the main computer and other equipment in the shelter, and assists the Watch Officer in determining the need for preventive maintenance or repair maintenance.

Analyst Shelters

The IAC's two analyst shelters are allocated to two major functions: order of battle analysis and target analysis.

Order of Battle Shelter

The Order of Battle shelter (Figure 7) is occupied by five individuals during IAC operations:

a. Order of Battle Officer--Reporting to the Watch Officer, the Order of Battle Officer is responsible for all IAC personnel and activities concerned with identification, location, strength, command structure, tactics, and disposition of the personnel, units, and equipment of enemy forces. He or she coordinates with the Watch Officer on the routing of digital, hard copy, and voice messages to analysts in the Order of Battle shelter.

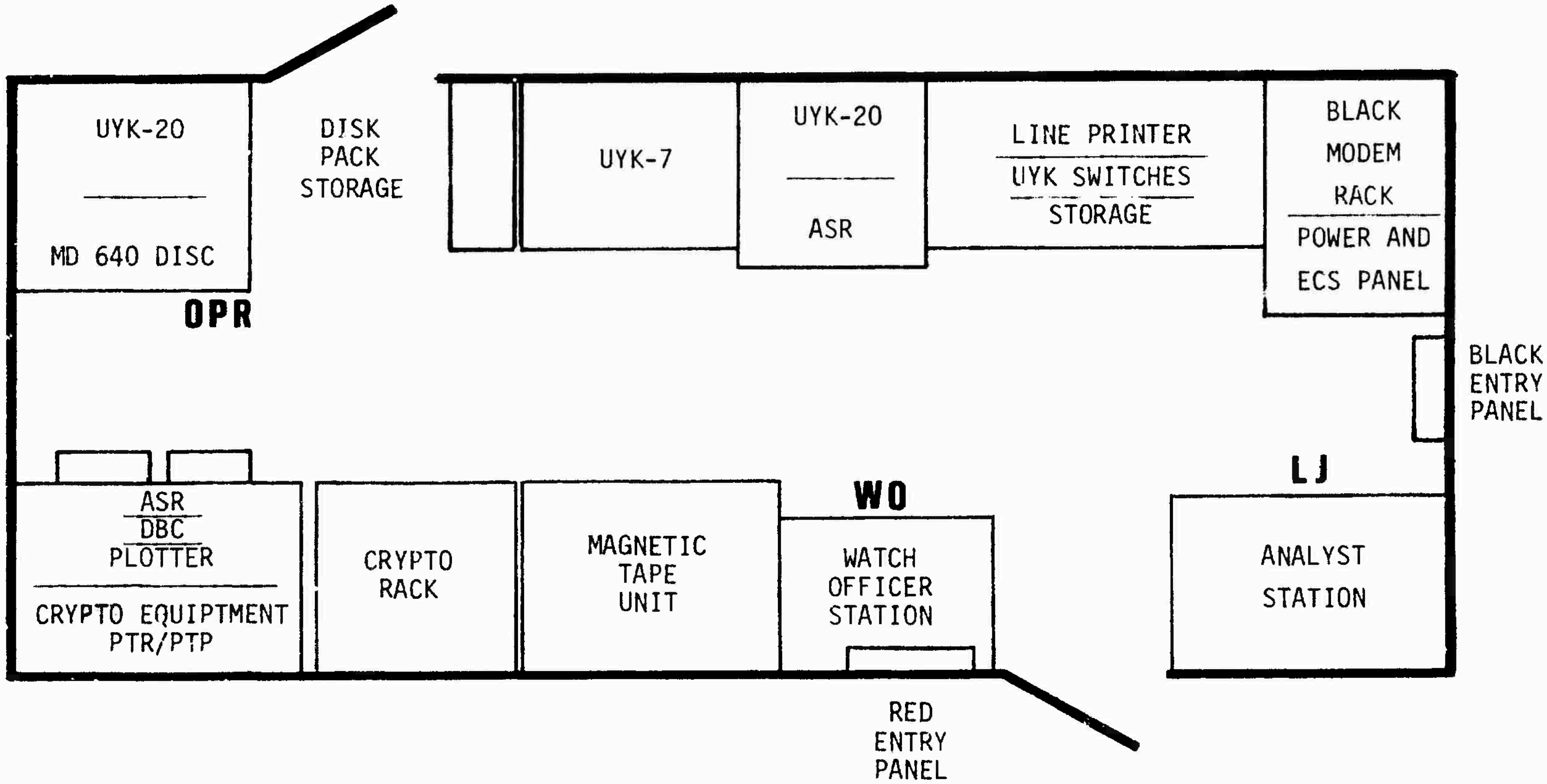

Figure 6. ADP/COMM Shelter Positional Assignments.

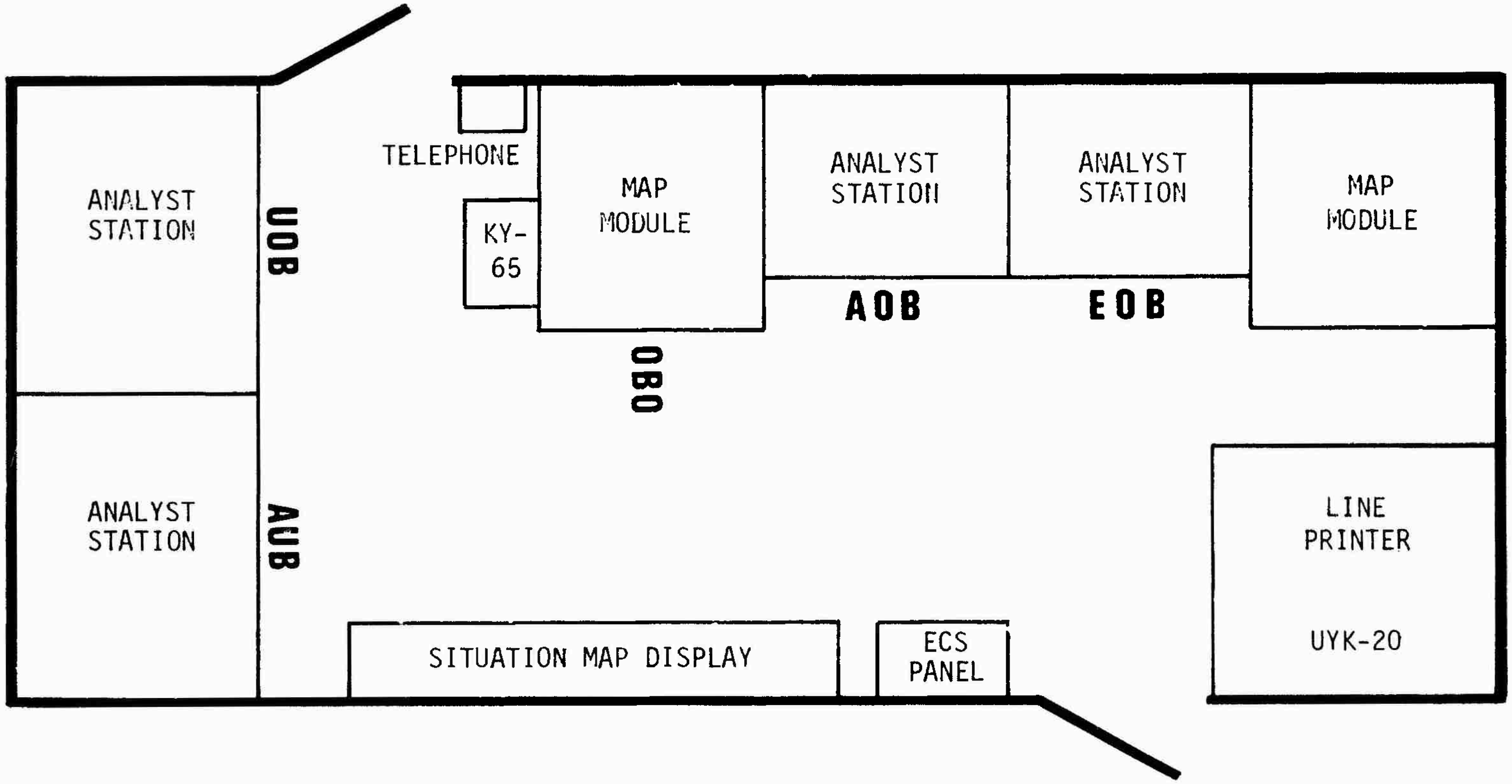

Figure 7. OB Shelter Positional Assignments.

b. Order of Battle Analysts--Order of Battle information, under the supervision of the Order of Battle Officer, is allocated to four intelligence analysts by the Watch Officer in coordination with the Order of Battle Officer. Typically, the information is divided between a Unit Order of Battle Analyst, an Assistant Unit Order of Battle Analyst, an Air Order of Battle Analyst, and an Electronic Order of Battle Analyst. The four analyst stations depicted in Figure 2 are normally allocated to the analysts as shown. However, any station can serve any function, and the allocation could be rearranged by the ADP/COM Operator at the direction of the Watch Officer.

Target Shelter

The Target shelter (Figure 8) is essentially identical to the Order of Battle shelter, differing only in the functions and personnel assigned to it:

a. Target Intelligence Officer--The Target Intelligence Officer reports to the Watch Officer, and is responsible for all IAC personnel and activities concerned with target intelligence and collections of intelligence. He or she coordinates with the Watch Officer on the routing of digital, hard copy, and voice messages to analysts in the Target shelter.

b. Targets Analyst and Assistant Targets Analyst--These two individuals are responsible for all IAC files concerned with target intelligence, or with geographical areas, complexes, or installations that might be used by friendly forces. Each occupies an QRU station.

c. Collections Analyst--The Collections Analyst actually works for and is directly responsible to the Collections Officer. However, since the analyst is physically located in the Targets shelter, he or she must interface and coordinate with the Targets Officer and Watch Officer. The Collections Analyst is responsible for Sensor, Relays, and Collections files in the IAC.

d. Reports Analyst--The Reports Analyst is responsible for maintaining all statistical information on the enemy, and for preparing and disseminating written intelligence reports, particularly the Intelligence Summary (INTSUM) and the Periodic Intelligence Summary (PERINTSUM).

User/Operator Interactions

A wide variety of interactions can occur in the MAGIS IAC. Two examples will illustrate the diversity of these interactions.

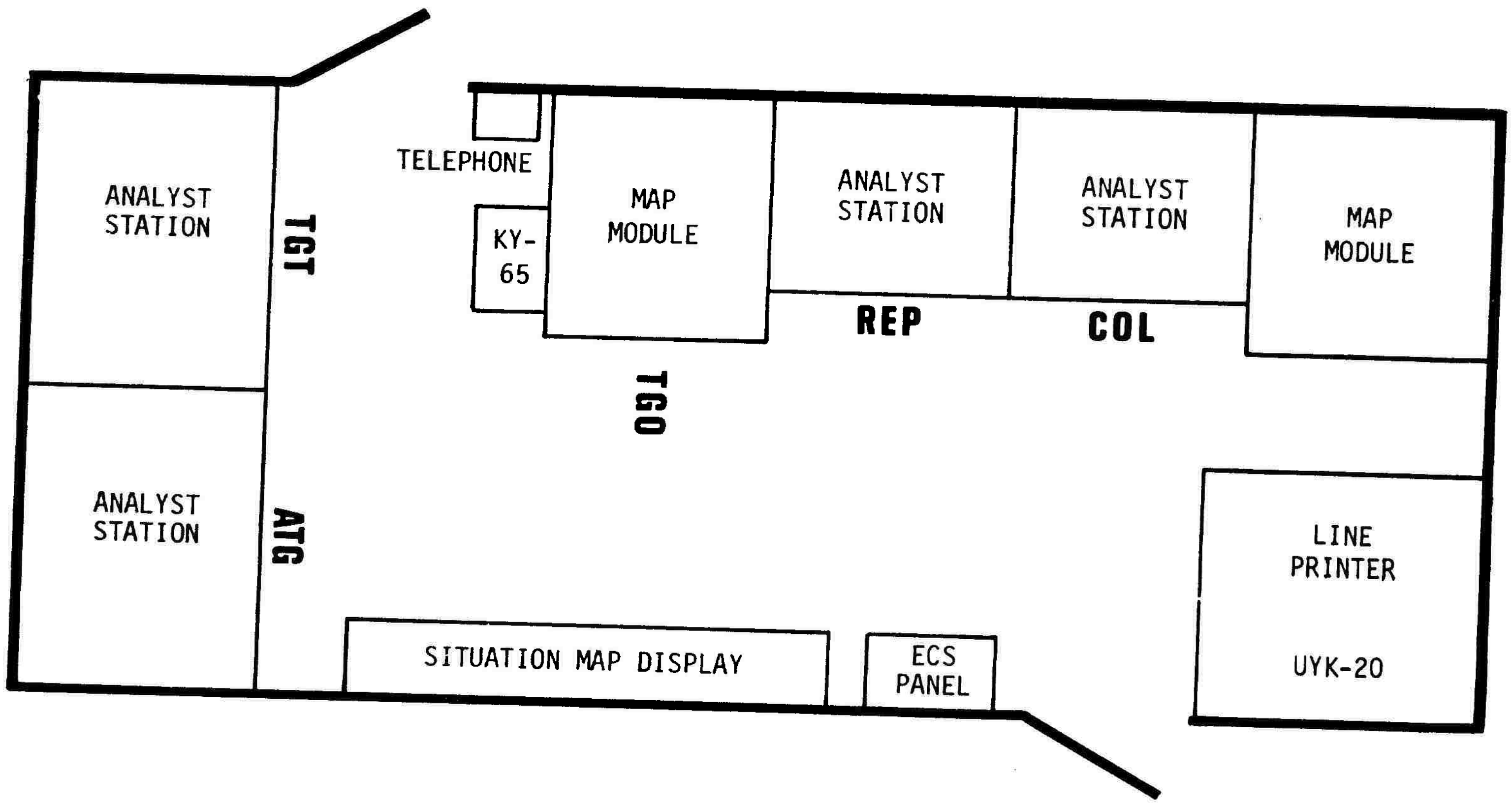

Figure 8. TG Shelter Positional Assignments.

Data File Updating

A hard copy intelligence message arrives at the ADP/COM shelter. The Watch Officer reviews the message and decides that it contains information relevant to both the Electronic Order of Battle Analyst in the Order of Battle shelter and the Targets Analyst in the Targets shelter. Under the Watch Officer's direction, the Log/Journal Clerk enters the message into the computer and routes it to the Electronic Order of Battle Analyst's station, where it enters the station's message queue. When the message reaches the top of the queue, the analyst reads and interprets the message, and performs the necessary data processing procedures to update the appropriate portions of the Order of Battle files. Assuming a straightforward transaction, the analyst does not interact with the Order of Battle Officer. Instead, he or she sends a user-to-user message to notify the Targets Analyst that a message is being sent over. He or she then transmits the message to the Targets Analyst's message queue.

When the message reaches the top of the queue, the Targets Analyst reads the message, then talks briefly with the Targets Intelligence Officer to clarify its interpretation. The analyst then performs the necessary data processing procedures to update the appropriate portions of the Target Intelligence files (this may require access to parts of the Order of Battle files; while analysts may write only in the files related to their areas of responsibility, all IAC files are available to all analysts on at least a read-only basis).

Report Generation

The Reports Analyst prepares an Intelligence Summary (INTSUM) four times daily. To gather material for the report, the analyst requests material from each of the other analysts. Each analyst calls up a segment of report format appropriate to his or her area of responsibility, and constructs that portion of the report, based on data from the relevant files. The analyst then transmits the format segment to the Reports Analyst. The Watch Officer prepares the conclusions paragraph of the report and sends it to the Reports Analyst via the Log/Journal Clerk. The Reports Analyst consolidates the various segments, adds statistical information from his or her own data files, and then produces a draft report for review by the Targets, Order of Battle,

and Watch Officers. They coordinate changes to the draft report, if necessary, and the analyst then produces the final report and delivers it to the Watch Officer.

DESIGN FEATURES

The MAGIS IAC combines elements of command language statements, menu selections, and "fill-in-the-blank" structured formats. Command strings are entered into a five-line section at the top of the vertical screen, and at the top of the left half of the horizontal screen. User-to-user and error messages also appear in this area. These command strings are used primarily to manipulate local data files (as opposed to manipulating data elements or records within a file). Thus, the user/operator uses command strings to construct local files from other files in the system, to retrieve files, to purge files, and to copy files. Menus are used generally to select particular functions, such as query, update, report, or plot. Menu selection transactions therefore constitute a relatively small portion of the user's/operator's activities.

Probably the greatest portion of his or her time is spent in filling in preformatted displays. Whether constructing a query to retrieve data, adding, changing, or deleting data to update a record, or constructing a report or plot, the user/operator fills in blanks in the appropriate display, transmits the screen contents to the CPU for processing, and receives the output, generally on the screen. He or she may, however, route the output to the printer or plotter, if desired.

The IAC has a number of design features intended specifically to help the user/operator with data entry. For example, the user/operator can press a HELP function key to obtain a list of legal entries for a given data field. Also, after constructing a query, update, report, or plot message, the user/operator can save the message in his or her personal file for re-use later. Thus, the IAC user/operator has a kind of macro capability that permits him or her to avoid repeating frequently used procedures. Additionally, the provision of personal, or "shoebox," files allows the user/operator to save procedures and information of particular use to him or her.

The designers of the IAC's newer QRU averted a possible negative transfer of training situation. On the keyboard of the older version, the user must begin each keying transaction by first pressing a "TYPE" FFK, then typing in commands or pressing other FFKs, as appropriate. On the newer version, the necessity for the "TYPE" function, and consequently the "TYPE" FFK, were removed. In the same physical location, however, the designers installed a key (its label was not recorded in available documentation or notes) which has an operational functional only under certain conditions; inadvertently pressing the key, even repeatedly, evidently never constitutes an error. Therefore, the user/operator trained on the older QRU, where he or she became accustomed to pressing the "TYPE" FFK to initiate a transaction, can use the same physical movements on the newer version. Though the first keystroke is wasted, at least it does no harm.

There are, however, IAC design features that could have a negative impact on user/operator performance. Examples of these design features are presented below.

a. Command Area:

1. Design feature: The top five lines of the QRU are used for entering commands and receiving user-to-user and error messages. This area is cleared only when the user/operator takes direct action to clear it.

2. Transactional implication: When entering a new command into the command area, the new characters replace the old, in effect concatenating new material with old material already on the line.

3. Predicted transactional problem: The user/operator may experience difficulty in locating the cursor as his or her attention switches from the entry line to the keyboard or hard-copy document and back. He or she may also confuse new material with old.

4. Detection/revocation of the problem: The user/operator, particularly if naive or inexperienced, must attend closely to the entry line, to ensure a proper character entry sequence.

5. Consequences of the problem: The user's/operator's entry rate is slowed and the probability of error is increased, particularly for naive or inexperienced persons. Entry errors will force re-entry of the command and further decrease the volume of useful intelligence generated by the system per unit of time.

6. Recommended resolution: Provide a capability to erase any line in the command area on user/operator demand, or when the user/operator enters the first character on the line (provided he or she is not in screen edit mode).

b. Validity Checks:

1. Design feature: In updating the data base, the user/operator may need to enter two associated data items, such as, for example, the code name for an aircraft and a second code for the aircraft's operational role. The system evidently does not check the joint validity of these two items.

2. Transactional implication: The necessity to know, for example, aircraft code names and codes for aircraft roles imposes a heavy memory load.

3. Predicted transactional problem: If the user calls up a help list of aircraft roles and their codes, all possible roles and codes are listed, requiring longer search times and excessive opportunities to select the wrong code.

4. Detection/revocation of the problem: The system checks the validity of each of the individual entries. Because it does not check their joint validity, only the user/operator can detect such an error. If he or she doesn't detect it on the screen, then the error will be stored in the data base.

5. Consequences of the problem: Erroneous entries will degrade the integrity of the data base. Obvious absurdities ultimately will be detected by intelligence analysts or officers, or by the commander (for example, a FISHBED labeled as an airborne command post). Correction of such errors nonetheless will consume time required for other procedures. Other, more subtle errors may degrade the quality of intelligence on which the commander bases tactical decisions.

6. Recommended resolution: Break up help lists hierarchically. In the case of codes for aircraft roles, for example, require the user/operator to enter the name code, then display only the codes for aircraft roles that legitimately may be associated with that name code.

c. Report Generation:

1. Design feature: Constructing intelligence reports online by using the split screen capability is difficult and error prone.[3]

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[3]/Personal communication from analyst who demonstrated MAGIS IAC.

2. Transactional implications: Users/operators typically avoid use of split-screen capability in constructing intelligence reports.

3. Predicted transactional problem: Users/operators either print data for report on hard copy or else copy it by hand, then call up the report format and reenter the data.

4. Detection/revocation of the problem: Not applicable.

5. Consequences of the problem: Printing or handwriting hard copy followed by reentry delays the production of intelligence reports. Transcription and omission errors can degrade the quality of intelligence disseminated in reports.

6. Recommended resolution: Provide a capability for the user/operator to call up a segment of the report format on one-half of the split screen, and the relevant data on the other half. Also provide a capability to indicate portions of data to be moved, areas of the report format into which they are to be moved, and a command to execute the move.

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